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DEPARTMENT OF THE ARMY FIELD MANUAL

**CHEMICAL AND
BIOLOGICAL
WEAPONS
EMPLOYMENT**

**HEADQUARTERS, DEPARTMENT OF THE ARMY
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CHEMICAL AND BIOLOGICAL WEAPONS EMPLOYMENT

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CHAPTER 1

INTRODUCTION

1. Purpose

This manual provides guidance to commanders and staff officers in the employment of chemical and biological weapons. It contains a brief summary of background knowledge of chemical and biological agents and munitions and the procedures to be followed in planning their employment.

2. Scope

a. General. Considerations are limited to chemical and biological agents and delivery systems that are type-classified or expected to be type-classified during the period ending December 1965. The chemical agents are nerve agent GB, nerve agent VX, and blister agent HD. The agent delivery means are artillery and mortar shells, rocket and missile warheads, aircraft bombs, and spray devices. FM 3-10A contains the classification and characteristics of biological agents and information on biological munitions and delivery systems. Troop safety considerations are presented. This manual is applicable to nuclear and nonnuclear warfare.

b. Chemical Agents. Chapters 3 through 8 contain a discussion of chemical agents and their characteristics; factors affecting the employment of chemical agents; chemical munitions and delivery systems and the concepts for their employment; and target analysis, fire planning, and logistical considerations. Methods of chemical target analysis presented are suitable for fire planning and casualty assessment at all echelons of command having chemical fire planning and assessment responsibilities.

c. Biological Agents. Chapters 9 through 13 contain a discussion of biological agents and their characteristics; factors affecting the employment of biological agents; biological munitions and delivery systems and the concepts of their employment; and target analysis, effects assessments, and logistical considerations. Only the anti-personnel effects of biological agents are con-

sidered. The methods of biological weapons target analysis presented are suitable for biological fire planning and casualty assessment. The unique character of biological munitions supply and field management is presented.

d. Reliability. The data and procedures presented in this manual have been extracted or derived from official studies and from research and development documents. The potential performance of materiel is based on field trial data with simulants and selected live agents and on theoretical calculations and assumptions developed from mathematical models. The procedures are therefore subject to change as may be required by future developments or refinements. It should be noted that the flow of a chemical or biological agent cloud over the terrain cannot be predicted with a high degree of precision. This is due principally to the inability to predict accurately the prevailing atmospheric conditions of the area under consideration with respect to the diffusion and dissipation of an agent cloud. Nevertheless, the methods and procedures presented here provide information with sufficient accuracy to be used with reasonable confidence.

e. User Comments. Users of this manual are encouraged to submit recommended changes or comments to improve the document. Comments should be keyed to the specific page, paragraph, and line of the text in which change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded direct to the Commandant, U.S. Army Chemical Corps School, Fort McClellan, Ala.

3. The Role of Chemical Agents in Military Operations

a. Chemical weapons increase the flexibility of the integrated weapons systems and place at the commander's disposal a highly effective means of conducting antipersonnel operations.

b. In the conduct of military operations involv-

ing chemical weapons, some factors that should be considered are—

- (1) The chemical agents discussed herein do not destroy materiel. On the contrary, they allow the physical preservation of industrial complexes, cultural institutions, lines of communications, and other facilities and materiel that may be useful to friendly forces or that merit preservation for political or economic reasons.
- (2) Chemical munitions do not produce physical obstacles to maneuver, since they cause minimal destruction, blowdown, rubble, and similar barriers. Agents that produce a persistent effect, however, will create a hazard to friendly troops.
- (3) Chemical agents may be employed to produce a variety of effects ranging from harassment to lethality.
- (4) Toxic chemical clouds penetrate fortifications and similar structures that are not airtight.
- (5) Because of their area coverage effect, chemical agents, used in mass, are particularly effective in attacking targets whose location is not precisely known.
- (6) Chemical munitions are particularly effective for producing casualties among dug-in personnel who are not provided with chemical protection.
- (7) Chemical agents increase the flexibility of the entire spectrum of firepower available to the commander.
- (8) Chemical agents may be used to follow up and exploit advantages gained by other means.

- (9) Because the effectiveness of chemical agents on the target is influenced by the type and quantity of agent employed and by the method of dissemination, meteorological factors, conditions of the target, and protection and training of enemy troops, it is difficult to predict the results of employment accurately.
- (10) Chemical agents may produce hazards to friendly forces because of residual contamination and cloud movement.

4. Chemical Agents

a. The following three type-classified chemical agents provide commanders flexibility in their employment of chemicals.

- (1) Nerve agent GB is a rapid-acting lethal agent that is used primarily for respiratory effects against unprotected personnel and for surprise attack against personnel having masks available.
- (2) Two agents are used in circumventing the protective mask.
 - (a) VX is a slow-acting lethal nerve agent when absorbed percutaneously. If inhaled as an aerosol or vapor, VX acts as rapidly as GB and is more toxic.
 - (b) HD is a slow-acting casualty agent with a limited lethal effect. It attacks the skin in liquid or vapor form and is also effective by inhalation.

b. The following figures describe GB and HD in more detail. Detailed information on VX is contained in FM 3-10A. More comprehensive data on chemical agents are in TM 3-215.

1. Primary use.....	Nonpersistent, rapid-acting lethal agent used primarily for respiratory effect.
2. Average time to incapacitation.....	15 minutes after exposure to an incapacitating dosage; for lethal dosages, death in 5 minutes after appearance of symptoms if untreated.
3. Duration of incapacitation.....	1 to 5 days for return to duty. (30 to 60 days for return to normal blood cholinesterase level.)
4. Signs and symptoms.....	Tightness of chest, pinpointing of eye pupils, dimness of vision, excessive sweating, drooling; followed by tension, giddiness, tremors, confusion, slurred speech, weakness, convulsions, and death.
5. Physiological effects.....	Nerve poison; slow detoxification by body (60 days); effects of successive small dosages considered cumulative for short periods of time (weeks).
6. Route of entry.....	Inhalation; percutaneous entry by liquid or high vapor concentration is unlikely in the field because of the high dosage required.
7. Protection.....	Mask against vapor; protective clothing against liquid agent.
8. Limitations.....	Mask offers adequate protection against vapor for trained and warned personnel.
9. Duration of hazard.....	The area in and around shell or bomb craters will be contaminated and will remain a hazard to unprotected personnel for periods ranging from 6 hours to several days.
10. Physical properties.....	Clear, colorless, odorless liquid; freezing point minus 56° C (−69° F.); boiling point 147° C (297° F.); evaporates at approximately the same rate as water.

Figure 1. Characteristics of nerve agent GB.

1. Primary use----- To cause delayed casualties by liquid and vapor effect on the skin and eyes and by vapor effect through the respiratory system.
2. Average time to incapacitation- Eye effect 3 to 12 hours; skin effect 3 to 24 hours.
3. Duration of incapacitation----- Eye effect 1 to 7 days; skin effect 1 to 4 weeks.
4. Signs and symptoms----- Inflammation of eyes; redness of skin; blistering; ulceration.
5. Physiological effects----- Produces blisters and destroys tissues.
6. Route of entry----- Skin absorption of vapor or liquid and inhalation of vapor.
7. Protection----- Mask, ointment, and protective clothing.
8. Limitations----- Limited effectiveness in freezing weather; greater dosages are required for casualty production than are required with GB or VX.
9. Duration of hazard----- 36 hours to several days. See figure 2.1d.
10. Physical properties----- Clear oily liquid with garliclike odor; moderately volatile; freezing point 14° C. (57° F.); boiling point 228° C. (442° F.).

Figure 2. Characteristics of blister agent HD.

Times given indicate approximate time after contamination that personnel may operate in the area

Task	Terrain	Protection (Based on expenditures between 240 and 1,200 pounds of HD per hectare)			
		With protective clothing and wearing masks		Without protective clothing ¹	
		Temperature		Temperature	
		16°-27° C. (60°-80° F.)	Above 27° C. (80° F.)	16°-27° C. (60°-80° F.)	Above 27° C. (80° F.)
		Hours	Hours	Days	Days
TRAVERSAL ² (Walking across area up to 2 hr).	Bare soil, sand, or short grass-----	0	0	³ 1½	³ 1½
	Low vegetation-----	4	2	³ 1½	³ 1½
	High vegetation, including jungle and heavy woods.	12	6	³ 4	³ 2
ADVANCE UNDER FIRE (Contact with ground, 1 hr; total time in area, 2 hr).	Bare soil or low vegetation-----	24	8	³ 3	³ 2
	High vegetation, including jungle and heavy woods.	48	24	³ 6	³ 4
OCCUPATION (Without hitting ground, 24 hr) --	Bare soil or low vegetation-----	1	1	⁴ 4	⁴ 3
	High vegetation, including jungle and heavy woods.	1	1	⁴ 4	⁴ 3
OCCUPATION (Involving advance under fire, 24 hr).	Bare soil or low vegetation-----	24	8	⁴ 4	⁴ 3
	High vegetation, including jungle and heavy woods.	48	24	⁴ 6	⁴ 4

¹ For men walking in a contaminated area for 2 hours without protective clothing, the limiting factor is the vapor.

² For men with protective clothing, when traversal is made in daylight and areas of heavy contamination can be avoided or decontaminated, the times can be reduced to about one-half of those indicated above.

³ Wearing masks.

⁴ Not wearing masks.

Figure 3. Duration of HD hazard in target area.

CHAPTER 2

PRINCIPAL FACTORS AFFECTING CHEMICAL AGENT EMPLOYMENT

Section I. INTRODUCTION

5. General

Some of the principal factors that determine the behavior and tactical effectiveness of chemical agents are the method of dissemination, the weather, and the terrain in the target area. Other

important factors are discussed in chapters 5 through 7. These factors are the level of physical and personal protection of target personnel, the level of training of enemy troops, and the target characteristics.

Section II. METHODS OF DISSEMINATION

6. Bursting-type Munitions

These munitions include bombs, warhead bombs, rockets, and artillery and mortar shells. When these munitions burst on target, most of the agent is disseminated as liquid splash, vapor, or aerosol. Of the remainder of the agent, part is driven into the crater formed by the burst, and part is decomposed by the explosion. When there are a number of bursts in the target area and the conditions are favorable, clouds from adjacent bursts merge, thus forming a continuous cloud. In the case of an air burst, there is no loss due to cratering effect, and a maximum of agent

return is achieved. If the agent is being disseminated in aerosol or vapor form, the greater agent return will be offset by the fact that much of the agent will remain well above ground level.

7. Spray-Type Munitions

GB, HD and VX chemical agents may be disseminated by spray devices mounted on aircraft. A toxic chemical agent spray mission is most effective when released simultaneously by the required number of aircraft flying at the desired height of release. A sample casualty level pattern produced by aircraft spray is shown in figure 4.

Section III. METEOROLOGICAL FACTORS

8. General

The reliability of the prediction of chemical agent cloud behavior for a chemical operation is dependent upon the completeness and accuracy of forecasts of related meteorological conditions. Temperature, temperature gradient, wind, and precipitation are the major meteorological factors to consider in chemical operations, and of these the temperature gradient has the greatest influence on chemical munitions requirements. Though these factors influence the effectiveness of chemical agents deposited on the ground, they are of far greater importance because of their effect upon

the behavior of chemical clouds. In the assessment of the possible effects of toxic chemical clouds, a target analyst cannot rely solely upon rules of thumb, bare meteorological data provided, and the basic procedures given in this handbook for the estimation of munitions requirements and agent effects. The analyst must also consider the total environment of chemical clouds over the entire life span of their possible effectiveness. Based on experience, study, and the best possible information on meteorology and terrain in the zone of operations, the analyst must determine the possible avenues of toxic cloud travel and the

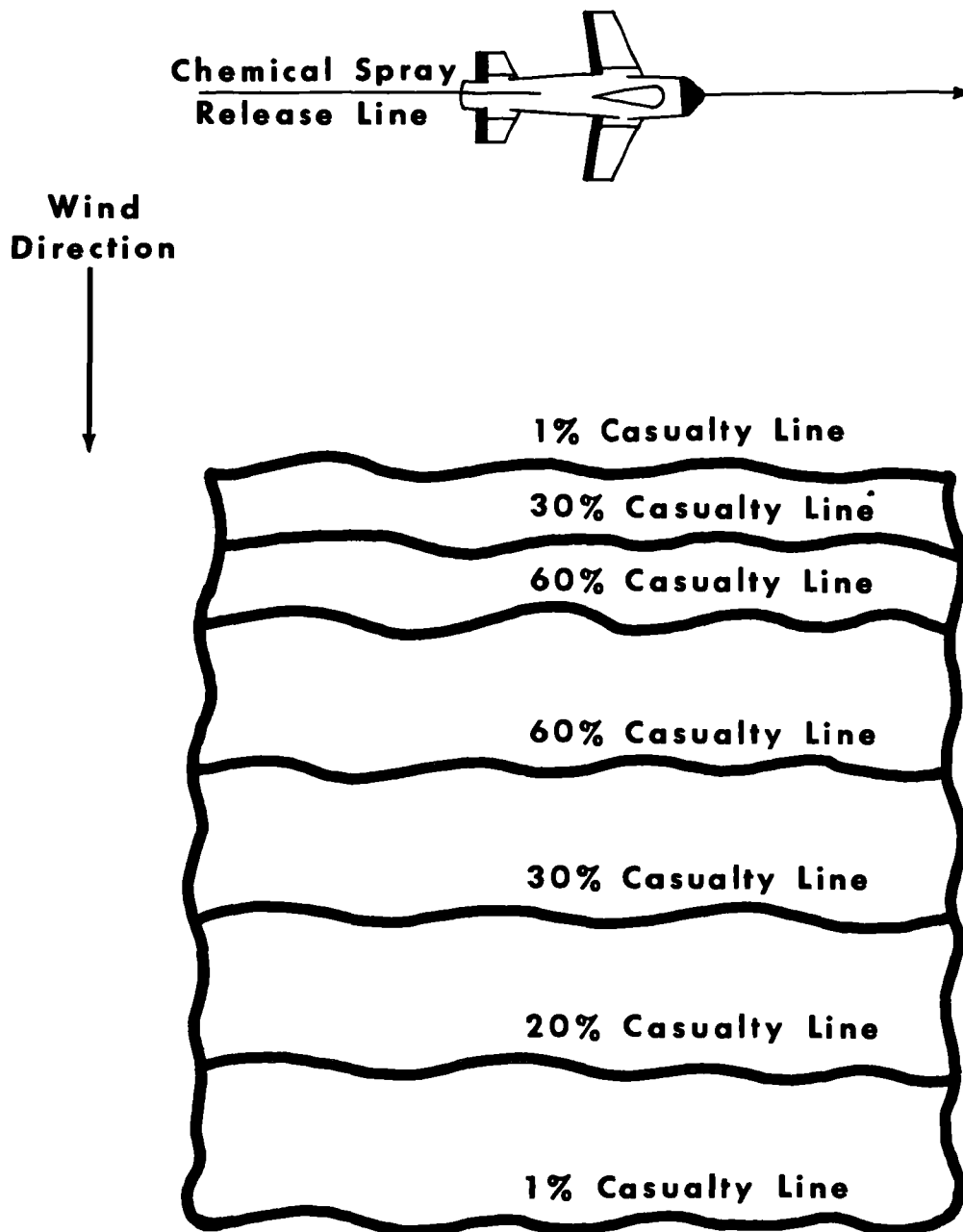


Figure 4. Elevated line source (Aircraft spray tank) casualty level contour pattern.

life expectancy of the cloud. He must consider overall meteorological effects as well as those factors operating in the target area. He must consider the effects of probable meteorological changes as they affect the chemical cloud over a period of time. Publications such as TM 3-240 give general guidance on weather and terrain effects, but it must be remembered that peculiarities of particular areas must also be considered.

9. Sources of Meteorological Information

a. The basic source of weather data is the Air Weather Service. This service will provide general meteorological data, give general predictions of weather in the zone of operations, and furnish detailed weather information as requested. Supplementing the Air Weather Service are artillery meteorological stations from which basic weather data can be obtained if requested.

Additional micrometeorological characteristics of the zone of operations are obtained through the following methods:

- (1) Aerial reconnaissance and observations.
- (2) Ground reconnaissance and observations.
- (3) Observations of fog, smoke, and dust in the zone of operations.
- (4) Field expedient methods for obtaining micrometeorological data in the vicinity of the target area.
- (5) Statistical studies of weather in the theater of operations.

b. A suggested format for transmission and recording of basic weather data is illustrated in appendix II. It is emphasized that in chemical target analysis, the weather predictions are required for a period of time after the attack as well as for the time of the chemical attack.

c. Normally, Air Weather Service detachments are stationed at field army, corps and division headquarters. From these sources a target analyst may obtain weather data and weather briefings, or he may request detailed operational and planning forecasts and climatological information.

10. Temperature

The rate of evaporation of chemical agents increases as the temperature rises. High temperatures cause personnel to perspire more freely, thus opening the pores of the skin and accelerating penetration of the skin by the agent. At low temperatures, extra layers of clothing increase the barrier to the skin.

11. Temperature Gradient

The temperature gradient is an expression of the difference in air temperature at two levels. In the United States Army, it is determined by subtracting the air temperature (Fahrenheit) measured one-half meter above the ground from the air temperature 2 meters above the ground. The three characteristic conditions that are associated with the temperature gradient follow:

a. *Lapse*. A decrease in air temperature with an increase in height is known as a *lapse* condition. Such a condition normally exists on a clear or partially clear day and is characterized by heat turbulence. It is the least desirable condition

for chemical operations because of rapid dissipation of agent clouds.

b. *Inversion*. An increase in air temperature with an increase in height is known as an *inversion* condition. This condition exhibits a minimum of turbulence and usually exists on a clear or partially clear night or early morning. This is the most desirable condition for chemical operations since the agent cloud tends to remain in the cooler layers of the air near the ground.

c. *Neutral*. A condition intermediate between lapse and inversion is known as a *neutral* condition. Such a condition prevails when there are small differences in temperature at the two levels and usually exists on heavily overcast days or nights, and shortly after sunrise and near sunset.

12. Wind

The wind is also an important weather element affecting the field behavior of chemical clouds. Of the wind characteristics, velocity and direction have greatest influence. Both characteristics are influenced by terrain and temperature gradient.

a. *Velocity*. Air moving over an irregular surface sets up eddies, or mechanical turbulence. This turbulence is similar to heat turbulence in that it acts to dissipate a chemical cloud. High wind velocities also cause the agent cloud to pass rapidly over the target area, thus reducing the exposure time. Some air movement is desired to blend the individual clouds of agent formed by each shell burst into a uniform cloud covering the target. Ideal wind velocities for chemical operations are 3 to 9 knots (approximately 6 to 16 kilometers per hour). Wind velocities in excess of 16 knots (approximately 30 kilometers per hour) are not suitable for nonpersistent effects.

b. *Direction*. Wind directs the travel of a chemical cloud. This fact must be considered in the release of an agent for coverage of a particular target and in the determination of the downwind hazard to friendly troops. The wind direction is the direction from which the wind blows and is expressed in terms of azimuth in mils or degrees.

13. Precipitation

Precipitation has an adverse effect on the behavior of chemical agents, since rain will wash away the liquid agent contamination and snow will cover it. Precipitation also washes agent vapors or aerosol clouds from the air and destroys some agents by hydrolysis.

Section IV. TERRAIN CONDITIONS

14. Contour

The contour of the ground alters the direction of cloud travel and may break a cloud into parts. Depressions and draws will retain portions of an agent cloud after open flat areas have been swept clear by the wind. Agent vapor which has infiltrated buildings and fortifications has a tendency to remain therein for prolonged periods after passage of the agent cloud. TM 3-240 gives detailed information on the effects of terrain on the field behavior of chemical agents.

15. Surface

Cloud size, crater size, degree of liquid contamination, and penetration of impact-detonating munitions are influenced by ground surface.

a. Soft Soil. A soft surface allows a shell to penetrate to greater depths before it explodes.

This results in a greater percentage of agent being driven into the crater wall and in an upward funneling of agent cloud, thus reducing surface effectiveness.

b. Hard Soil. A hard surface reduces penetration and cratering and minimizes the loss in the crater wall, thus enhancing the effectiveness of chemical agents.

c. Porous Soil. Porous soils (sand) absorb liquid agents, thereby slowing evaporation and reducing the hazard of liquid agent contamination.

16. Vegetation

Liquid agent spread on vegetation normally presents a greater contact hazard to troops than does agent on bare soil or hard surfaces. More effective agent cloud concentrations can be built up in the stable, protected air of a wooded area.

CHAPTER 3

CONCEPTS OF EMPLOYMENT

17. General

a. Introduction. Toxic chemical agents have tactical application in offensive and defensive military operations, under nuclear and nonnuclear conditions, and in limited or general wars. They may be used alone, or they may be used in conjunction with other types of fires to increase the effectiveness and flexibility of the entire spectrum of firepower available to the commander. Since the physiological effects of chemical agents may range from temporary incapacitation through lethality, the commander is provided a degree of flexibility in applying available combat power.

b. Sequence of Fires. When chemical fires are delivered immediately prior to or concurrently with high explosive or nuclear fires, the following should be considered:

- (1) The blast effect of nuclear detonations will affect the behavior of vapor or aerosol clouds covering the target.
- (2) The thermal effect of nuclear fires is normally sufficient to decompose chemical agents in the area of ground zero and its surroundings.
- (3) High explosive concentration on the ground will tend to dissipate the chemical agent clouds.
- (4) High explosive air bursts will have less effect on chemical agents on the ground and may even tend to blow agent vapor cloud toward ground levels.
- (5) Earth and debris displaced by nuclear or high explosive weapons will cover contaminated ground.
- (6) High explosive fires will force personnel to seek protection close to the ground and make them more vulnerable to agents deposited on the surface.

c. Area and Penetration Effect. Chemical clouds travel with the wind and may cover significant areas beyond their point of release. A toxic cloud can penetrate openings in field fortifications that cannot be penetrated by small projectiles,

fragments of high explosive shells, or significant amounts of thermal and nuclear radiation from nuclear detonations. Whereas small projectiles and shell fragments lose their effectiveness almost instantaneously, chemical agents remain effective from several minutes to hours, depending on the weather and terrain conditions.

d. Harassment. Lethal agents, such as GB and VX, may be employed in a harassing role by the occasional firing of a small number of rounds in conjunction with high explosive concentrations. Knowledge of the presence of these agents will cause the enemy to mask and take other protective measures that will impair his efficiency and weaken his morale. The frequent use of chemical agents in the harassing role reduces their effectiveness when used for surprise attacks.

e. Incapacitation. Because of the narrow margin between the incapacitating dose and the lethal dose of GB and VX, these agents should not be considered for use when incapacitation only is desired.

f. Fragmentation Effect. Under similar conditions and as a rule of thumb, the fragmentation effect of a nerve agent chemical shell is about one-half that of a comparable high explosive shell. However, this fragmentation effect does produce casualties in addition to those caused by the chemical agent. The fragmentation casualties from chemical munitions are considered as a bonus effect.

18. Chemical Attack for Nonpersistent Effect

Chemical agents are employed in a nonpersistent role when they are disseminated in vapor or aerosol form. Agent clouds are effective against personnel who are caught by surprise, are unprotected, have poor protective equipment, or are poorly trained in defensive measures.

a. Casualties Among Unprotected Personnel. Chemical agents readily achieve optimum casualty effects among personnel who are without protective equipment. Though there may be in-

stances in the initial phases of a general war when large groups of personnel will be without protection, it is expected that most enemy military and civilian personnel will have at least a protective mask shortly after the beginning of hostilities.

b. Casualties Through Poor Discipline or Equipment. The more important factors determining the number of casualties include the availability of effective warning devices, the rapidity with which unit personnel spread the alarm, the condition of the protective equipment, and the training in the use of protective equipment. Personnel who are most vulnerable to lethal agents because of failure to receive timely warning are those who are sleeping without protection, working or bivouacked in isolated groups, or engaged in activities such as reconnaissance, traffic control, and recreation.

c. Casualties Through Surprise. When enemy personnel are equipped with good protective equipment and are well disciplined in its use, the agent should be delivered on the target in the shortest possible time so that exposure to the agent occurs before there is time for personnel to react to its presence and take protective measures against it. Because of its high toxicity, relatively high volatility, and lack of odor, GB should be employed for surprise effects. Consideration should be given to achievement of surprise on targets downwind from the impact area due to lack of warning.

d. Casualties Through Massive Dosages Against Protected Personnel. When surprise cannot be achieved effectively against personnel with protective equipment, casualties may be obtained by the use of heavy dosages. While these dosages will not harm personnel with good equipment, properly used, they will achieve a degree of effectiveness against individuals with marginal equipment and against those who become even slightly careless in gas discipline. Among these will be personnel whose canisters are approaching the breaking point.

19. Chemical Attack for Persistent Effect

Liquid agents of low volatility are generally employed for persistent effect against permanent targets. These agents may be used for direct attack on personnel, or they may be delivered to contaminate terrain, equipment, and materiel. The principal objectives of a chemical attack for persistent effect are:

a. Circumvention of the Protective Mask. Agents which can penetrate the skin afford a means of circumventing the protective mask. To cause casualties by skin contact, liquid contamination is most effective in vegetated areas or on nonabsorbent surfaces. In combat situations effective decontamination of clothing is often tedious and difficult to accomplish, and detection of residual contamination is extremely difficult.

b. To Hamper or Restrict the Use of Terrain and Materiel. Contamination with toxic chemical agents restricts the use of terrain and materiel by the enemy. Contaminated terrain presents the following three courses of action to the enemy:

- (1) Avoid the contaminated area.
- (2) Decontaminate prior to traversal or occupancy.
- (3) Accept the risk of casualties commensurate with the protective measures taken.

Decontamination of the area imposes delay and a logistical problem of considerable magnitude. Contaminated equipment and supplies must be decontaminated before they are used, requiring time and logistical effort. If the enemy elects to traverse or occupy contaminated terrain, he may reduce the risk of casualties by use of protective clothing. In combat, it is unlikely that a unit can traverse a contaminated area on foot without suffering casualties.

20. Chemical Agents in the Offense

In the offense, chemical agents are employed effectively in the following situations:

- a.* On bypassed enemy forces—VX or HD.
- b.* On appropriate targets to assist in the isolation of the battlefields—any agent(s).
- c.* On enemy positions along the friendly axis of advance—GB.
- d.* On enemy reserves—any agent(s).
- e.* On fortified enemy positions in the objective—GB.
- f.* To assist in flank protection—VX or HD.
- g.* On targets too close to friendly forces for nuclear attack—any agent(s).

21. Chemical Agents in the Defense

In the defense, chemical agents are employed effectively in the following situations:

- a.* On appropriate targets to support security forces in delaying, deceiving, and disorganizing the enemy—any agent(s).

b. On assembly areas to hamper enemy preparation for attack—any agent(s).

c. On the enemy after he has launched his attack—any agent(s).

d. To contain the enemy penetration—GB.

e. To hamper the reinforcement of the enemy penetration—VX or HD.

f. To support a friendly counterattack—GB.

g. To hamper or restrict the use of favorable routes of approach—VX or HD.

22. Chemical Agents in Retrograde Movements

In retrograde movements, chemical agents are employed effectively in the following situations:

a. To cause attrition and delay and disorganize enemy pursuit—GB.

b. To canalize and delay the enemy, cause delayed casualties, restrict his use of materiel and facilities, and restrict his movement—VX or HD.

CHAPTER 4

CHEMICAL MUNITIONS AND DELIVERY SYSTEMS

23. Cannon-Delivered Chemical Munitions

Cannon-delivered chemical munitions consist of shells filled with toxic agents and fitted with fuze and burster. The shells within this class differ mainly in type and quantity of agent fill, type of fuze, caliber, and agent-to-burster ratio. The delivery systems differ mainly in angle of fire, flexibility, mobility, rate of fire, and time for delivery. Cannon artillery firing chemical munitions are capable of cross-country maneuvering and deep penetration.

24. Rocket-Delivered Chemical Munitions

This class of chemical munitions consists of chemical-filled warheads, either permanently attached to rockets or shipped separately for assembly at the launching site. Either type is capable of indirect fire. They differ in type and quantity of agent, fuzing, range, type warhead, launching capability, rate of fire, and response time. Small caliber chemical rockets are large-volume, rapid rate of fire weapons used for close support. Large caliber chemical rockets are used for single-round attack of targets at long ranges, functioning by air release of many self-dispersing, impact-functioning bomblets. Both types are suitable for large area coverages (areas greater than five hectares*) and have the same disadvantage of revealing their emplacement by flash and dust. Navy chemical rockets are used primarily for close support of landing operations or attack of shore targets. They may be used for attack of surface craft.

*One hectare is a 100-meter square.

25. Guided-Missile-Delivered Chemical Munitions

Chemical warheads are available for certain guided missiles. These warheads contain chemical agent filled bomblets and are interchangeable with other type warheads for the missile. The delivery system is limited in availability of missiles, rate of fire, response time, and close support capability. These delivery systems are used primarily for engaging targets at long range.

26. Aircraft-Delivered Chemical Munitions

Chemical munitions in this class consist of aerial bombs and clusters. They differ in weight, type and quantity of agent fill, single or multiple bombs, fuzing, and accuracy. Delivery is accomplished by fighters or bombers, which differ in range of flight, payload, accuracy, time for delivery, and type of targets engaged. Both the Navy and the Air Force have the capability for delivery of chemical bombs. See FM 3-10A and TM 3-200A for classified information.

27. Chemical Land Mines

Chemical land mines are filled with HD or VX and are used to aid in the establishment of barriers. No procedures are given for target analysis when chemical land mines are employed.

28. Chemical Munitions and Delivery Systems

A summary of characteristics and performance data of chemical munitions and delivery systems is tabulated in figure 5 for ready reference by the target analyst. Where no data appear, the information is not available or is of limited reliability. Where asterisks appear in the columns, the data are close approximations derived from developmental equipment.

Line	1 Munition	2 Agent	3 Delivery system	4 User	5 Employment data			
					(a)		(b)	(c)
					Range (1) (Meters) (2)		Error	Fuze (Capability)
					Maximum	Minimum		
1	Shell, M2A1.....	HD	4.2-inch Mortar.....	US ARMY USMC	3,930.....	180.....	← Obtain from delivery unit or appropriate firing tables →	M8PD.....
2	Shell, M380.....	GB	105-mm Howitzer, M2A1, M2A2, M4, M4A2, M52.	US ARMY USMC	11,140.....	862.....		M508PD.....
3	Shell, M60.....	HD	105-mm Howitzer, M2A1, M2A2, M4, M4A2, M52.	US ARMY USMC	11,140.....			M51A5PD.....
4	Shell, M121.....	GB	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14,950.....			M508PD.....
5	Shell, M110.....	HD	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14,950.....			M51A5PD.....
6	Shell, T__ (M121).....	VX	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14,950.....			T76E6VT 1.....
7	Shell, M122.....	GB	155-mm Gun, M2, M53.....	USMC.....	23,500.....			M508PD.....
8	Shell, M104.....	HD	155-mm Gun, M2, M53.....	USMC.....				M51A5PD.....
9	Shell, Gas, 175-mm.....	GB	M107 Gun (SP).....	US ARMY	31,500.....	180.....		
10	Shell, Gas, 175-mm.....	VX	M107 Gun (SP).....	US ARMY	31,500.....	180.....		VT-M514A1.....
11	Shell, T174.....	GB	8-inch Howitzer, M2, M2A1, M55.	US ARMY USMC	16,930.....			M51A5PD.....
12	Shell, T174.....	VX	8-inch Howitzer, M2, M2A1, M55.	US ARMY USMC.	16,930.....		← Obtain from delivery unit →	T2061VT.....
13	Rocket, M55, 115-mm (BOLT).....	GB	Launcher, M91.....	US ARMY USMC.	10,970.....	2,740.....		M417PD.....
14	Rocket, M55, 115-mm (BOLT).....	VX	Launcher, M91.....	US ARMY USMC.	10,970.....	2,740.....		T2061VT.....
15	Warhead, M79, 762-mm (HON- EST JOHN).	GB	Rocket, M31A1C Launcher, M386.	US ARMY USMC.	24,960.....	8,500.....		T2075 Mech Time.....
16	Warhead, E19R2, 762-mm (HONEST JOHN).	GB	Rocket, XM50 Launcher, M386.	US ARMY USMC.	33,830.....	8,500.....		T2075 Mech Time.....
17	Warhead, E19R2, 762-mm (HONEST JOHN).	VX	Rocket, XM50 Launcher, M386.	US ARMY USMC.	33,830.....	8,500.....		T2075 Mech Time.....
18	Warhead, E20, 318-mm (LIT- TLE JOHN).	GB	Rocket, XM51 Launcher, XM80.	US ARMY USMC.	18,290.....	3,200 1.....		T2075 Mech Time.....
19	Warhead, E21, (SERGEANT).....	GB	Rocket, Launcher.....	US ARMY.	139 km.....	50 km.....	304m.....	Preset Radar.....
20	Warhead, E21, (SERGEANT).....	VX	Rocket, Launcher.....	US ARMY.	139 km.....	50 km.....	304m.....	Preset Radar.....
21	Bomb, M34A1, 1000-lb, Cluster.....	GB	Fighter, Bomber.....	USAF.....	Range of Aircraft.		← Obtain from delivery unit →	M152E3 Mech Time.....
22	Bomb, MC-1, 750-lb.....	GB	Fighter, Bomber.....	USAF.....	Range of Aircraft.			M905BD.....
23	Projectile, 5"/38, MK53, MOD O.	GB	5-inch Gun.....	US NAVY.	16,450.....			MK29MOD3PD.....
24	Projectile, 5"/54, MK54, MOD O.	GB	5-inch Gun.....	US NAVY.	19,200.....			MK30MOD3PD.....
25	Warhead, Rocket, 5" MK40, MOD O.	GB	Launcher, MK 105 Rocket, M40, MOD O.	US NAVY.	4,200.....			MK30MOD3PD.....
26	Warhead, Rocket, 5", MK40, MOD O.	HD	Launcher, MK 105 Rocket, M40, MOD O.	US NAVY.	4,200.....			MK30MOD3PD.....
27	Bomb, MK94, MOD O.....	GB	Fighter, Bomber.....	US NAVY.	Range of Aircraft.			AN-M103A1ND M195 BD (IM- PACT).
28	Bomb, M70A1.....	HD	Fighter, Bomber.....	US NAVY.	Range of Aircraft.			AN-M158ND (IM- PACT).
29	Mine, Land, Chemical, M23.....	VX	N/A.....	US ARMY.	N/A.....	N/A.....	N/A	
30	Mine, Land, Chemical, One- Gallon.	HD	N/A.....	US ARMY.	N/A.....	N/A.....	N/A	

See notes at end of figure.

Figure 5. Chemical munitions and delivery systems.

5 Employment data—Continued						6 Functioning and physical characteristics of CML munitions				
(d) Time for delivery		(e) Organization	(f) Rate of fire per weapon	(g) Height of burst	(h) Diameter (meters) of impact area (single rd) ²	(a) Weight of munition (kg)	(b) Weight of agent (kg)	(c) Effective weight of agent (kg) ³	(d) Function- ing effi- ciency of munition (percent)	(e) Agent dissemi- nation efficiency
(1) Preplanned	(2) Target of opportunity									
		6 Mort/Plt.....	30 Rds/2 min.....	GND.....	18.....	10.8	2.72		99	
		8 Mort/Btry.....	105 Rds/15 min.....							
	1-3 min.....	6 How/Btry.....	6 Rds/1/4 min.....	GND.....	27.....	16.1	.739		99	
			18 Rds/4 min.....							
	1-3 min.....	6 How/Btry.....	6 Rds/1/4 min.....	GND.....	11.....	15.2	1.22		99	
			18 Rds/4 min.....							
	1-5 min.....	6 How/Btry.....	3 Rds/1/4 min.....	GND.....	49.....	45.9	2.95		99	
			12 Rds/4 min.....							
	1-5 min.....	6 How/Btry.....	3 Rds/1/4 min.....	GND.....	20.....	42.0	4.4		99	
			12 Rds/4 min.....							
	1-5 min.....	6 How/Btry.....	3 Rds/1/4 min.....	20m ¹		45.9	2.95		99	
			12 Rds/4 min.....							
	1-5 min.....	4 Gun/Btry.....	2 Rds/1/4 min.....	GND.....	49.....	45.9	2.95		99	
			8 Rds/4 min.....							
	1-5 min.....	4 Gun/Btry.....	2 Rds/1/4 min.....	GND.....	22.....	43.0	5.31			
			8 Rds/4 min.....							
		4 Gun/Btry.....		GND.....		66.8	6.68			
		4 Gun/Btry.....		GND.....		66.8	6.04			
	1/2-6 hr.....	4 How/Btry.....	6 Rds/4 min.....	GND.....	76.....	97.0	7.12		99	
			10 Rds/10 min.....							
	1/2-6 hr.....	4 How/Btry.....	6 Rds/4 min.....	20m ¹		97.0	7.12		99	
			10 Rds/10 min.....							
	30 min.....	36 Lebr/Bn.....	45 Rkt/Lebr/15 sec.....	GND.....	46.....	26.4	4.80		99	
	30 min.....	36 Lebr/Bn.....	45 Rkt/Lebr/15 sec.....	20m ¹		26.2	4.54		99	
	15 min.....	2 Lebr/Bn.....	2/Hr.....	Variable.....	Variable.....	737	177.5	104.8	95	62 per- cent.
	15 min.....	2 Lebr/Btry.....	2/Hr.....	Variable.....	Variable.....	568	210	171	95	86 per- cent.
	15 min.....	2 Lebr/Btry.....	2/Hr.....	Variable.....	Variable.....	568	210			
	15 min.....	4 Lebr/Btry.....	2/Hr.....	Variable.....	Variable.....	119	30			
15 min.....	120 min.....	4 Lebr/Bn.....	2/Day.....	Intervals of 1,524m.....	Variable.....	744	190			
15 min.....	120 min.....	4 Lebr/Bn.....	2/Day.....	Intervals of 1,524m.....	Variable.....	744	190			
	15 min + flight time.....		2-6/Ftr.....	Variable.....	170.....	513	89.6		90	
	15 min + flight time.....		4-18/Bmbr.....							
			2-6/Ftr.....	GND.....	127.....	322	99.9			
			4-27/Bmbr.....							
				GND.....	35.....	25.1	1.47			
				GND.....	40.....	29.1	2.02			
			48 Rkt/Lebr/ 1 min.....	GND.....	49.....	22.9	2.18			
			48 Rkt/Lebr/ 1 min.....	GND.....						
				GND.....	90.....	222	49.8			
				GND.....	29.....	58.0	272			
						10.50	5.23			
						5.45	4.50			

¹ Estimated.

² Instantaneous agent area coverage 30 seconds after detonation.

³ Values are the product of values given in columns 6(b), 6(d), and 6(e). Since values for 6(e) are not available, values for 6(c) cannot be computed at this time.

Figure 5.—Continued

CHAPTER 5

CHEMICAL TARGET ANALYSIS AND FIRE PLANNING

29. Introduction

a. Chemical target analysis is a process of examining the existing and potential targets to determine vulnerability and suitability for chemical attack and the capability of available chemical weapons for such attack. Based on this analysis, recommendations for the employment of chemical agents are prepared and presented to the commander and his staff. Since the characteristics of targets are rarely well known and the described behavior of chemical agents is primarily based on statistical treatments, the results of analyses should be recognized as predictions and as such represent only approximations of actual results. Nevertheless, such predictions have sufficient accuracy to meet the needs of the field commander.

b. Chemical target analysis consists essentially of the following steps:

- (1) Obtain essential target information.
- (2) In consonance with the commander's concept of operations, determine which targets are suitable for chemical attack.
- (3) Select suitable agents for producing the desired effects on each target.
- (4) Determine the quantitative chemical munitions requirements or amount of agent for attack of each target.
- (5) Determine the delivery means available and capable of disseminating the selected agents on each target.
- (6) Determine troop safety requirements.
- (7) Make recommendations for the employment of chemical weapons.
- (8) Make poststrike analysis.

c. The four basic situations that require target analysis are:

- (1) The planned employment of chemical weapons to support the mission (target analysis).
- (2) The after-the-fact situation, when the planned weapon has been used against the enemy (poststrike analysis).
- (3) The anticipated enemy employment of

chemical weapons (analysis to determine own vulnerability).

- (4) The after-the-fact situation, when the enemy has employed chemical weapons (damage assessment).

30. Essential Target Information

Specific targets may be designated by the commander for consideration in chemical target analysis. These targets will receive planning priority. In addition, the target analyst will consider other targets that might be of importance to present or future operations. Information pertinent to all these targets may be obtained from:

- a.* Intelligence reports.
- b.* Situation reports.
- c.* Technical intelligence reports.
- d.* Special studies.

31. Targets Suitable for Chemical Attack

Certain target characteristics, which influence the selection of an agent-munition combination, should be carefully considered in chemical fire planning. These target characteristics are: composition, location, size, shape, permanence, enemy level of protection, weather, and terrain. The effects of weather and terrain on agent behavior were discussed in chapter 3.

a. Composition. So far as composition is concerned, targets may be classified into those consisting primarily of personnel and those consisting mainly of installations, equipment, and materiel. Chemical weapons will be used normally against the former, although they may also be employed to contaminate the latter.

b. Location. Three aspects of target location that must be considered in planning chemical fires are the target's relationship to the plan of maneuver, distance from possible delivery means, and proximity of friendly troops or civilian populations to the target. The first may indicate the use of an agent producing a nonpersistent effect if the target area must be traversed or occupied by friendly troops, the second may preclude the

use of some delivery means because of range limitations, and the third may dictate coverage limits or type of agent effect to minimize troop or civilian hazard.

c. Size and Shape.

- (1) *Size.* Downwind casualties resulting from a chemical attack being considered a bonus, the impact patterns of particular weapons or batteries available will automatically limit area coverage capability and the size of target that can be engaged successfully. In a modern nuclear battlefield, the platoon size unit will usually be the only target of comparatively constant size (about 300 meters by 200 meters) and of even density. As the targets increase in size, the clustering of personnel within the target area will vary, but most of the area will be unoccupied. In a particular attack of a large target where subunits are not accurately located, munitions requirements must be extensive to insure chemical agent effects against the separate clusters of personnel. For classification purposes, targets of about five hectares or less are called small area targets; they are usually engaged by cannon artillery. Large area targets are those over five hectares in area or larger than platoon size; while they may be engaged by massing cannon artillery, these targets more properly belong to an area type weapon.
- (2) *Shape.* The shape of a target will influence the selection of weapons and possibly the disposition of firing units, in order to allow characteristic impact patterns to cover the target with the required agent concentration. For example, a system with a circular dispersion pattern of 500 meters diameter could not be used effectively and economically to engage a linear target 100 meters wide and 2,000 meters long.
- (3) *Impact patterns of weapons related to target size and shape.*
 - (a) Missiles and rockets that disperse munitions in the form of bomblets will produce approximately circular impact patterns whose size will vary directly with the height of the bomblet release. The dosage or casualty level

within the impact area will vary inversely with the size of the area and as dictated by meteorological conditions. FM 3-10A gives some representative area coverages for the HONEST JOHN rocket. The pattern of chemical agent bomblets dropped from aircraft will depend upon the method and height of release.

- (b) Area rockets will have characteristic impact areas at different ranges as shown in figure 10 for the M55 rocket (BOLT). The size of the pattern and meteorological conditions will determine the casualty level produced within the impact area.
- (c) Cannon artillery batteries firing chemical agents against personnel with protection available will normally fire at center-of-target range using a normal or linear sheaf, the latter being preferable. The pieces will fire as rapidly as the crews can load and fire, allowing normal dispersion to distribute rounds. Battery impact patterns, thus fired, will cover an area about 300 meters wide and about 200 meters deep. If time of delivery and the establishment of high dose levels is not of concern, area coverage techniques of fire may be used with a resulting larger impact area for a battery.

d. Permanence. Permanence refers to the continuance of a target in the same condition or place. In chemical fire planning, consideration must be given to the speed with which a target can be detected, identified, analyzed, and attacked, all of which will depend largely upon the availability of timely and adequate intelligence and the response time of delivery systems. Though a comparatively high degree of permanence is desired of a target to be attacked with chemicals, the rapid response time of some delivery systems also allows the employment of chemical agents against fleeting targets.

e. Level of Protection. Level of protection determines the relative vulnerability of personnel to chemical agent effects. The following factors will have an effect on agent choice and employment: Estimations of the physical conditions of troops, morale of troops, the state of training in the use of protective measures, overhead cover, and availability of protective equipment and

shelters. Poorly trained troops will be particularly vulnerable to surprise attack through the respiratory route.

32. Selection of Agent

The desired effects will be defined or implied by the commander in terms of immediate or delayed casualties, lethal or nonlethal action, percentage of casualties in the target area, or barrier and harassing effect. Consideration of the factors given below will normally allow the proper selection of the agents for the desired effect on the target.

a. Enemy protection levels will determine casualty rate and influence the choice of agent. If the enemy has no protective equipment, GB will be employed for immediate lethal effect, VX for delayed lethal effect, and HD for delayed incapacitation. If the enemy is equipped with protective masks only, GB will be used when surprise can be attained, VX will be used for delayed lethal effect, and HD will be used for delayed incapacitation. Combinations of agents may also be used. When the enemy has extensive protective equipment, employment of chemical agents for percutaneous effect is indicated, unless surprise can be achieved.

b. The existing weather is a second factor to consider in agent choice and will determine whether the desired casualty effects can be produced. Detailed weather effects are given in chapter 3.

c. Terrain effects are given in chapter 3.

d. Troop safety considerations are presented chapter 8.

33. Determination of Quantitative Chemical Munitions Requirements

a. In determining munitions requirements, the following assumptions are made:

- (1) Area coverage is directly proportional to the weight of agent placed on the target.
- (2) Target personnel are evenly distributed in the target area.
- (3) Chemical agent is evenly distributed on the target.
- (4) The percentage of casualties achieved against a target consisting of unprotected personnel is equivalent to the percentage of the target area covered by a casualty-producing dosage.

b. Since area coverage for a specific agent effect is approximately proportional to the weight of agent delivered, chemical munitions requirements for the target may be expressed in terms of 155-mm munitions. This equivalence does not consider variation in effects due to rates of fire or dispersion patterns, but these factors must be considered in practical application as shown in chapter 6. The 155-mm chemical equivalent system is intended for use by a target analyst and by artillery fire direction personnel, since it allows maximum flexibility in weapons choice and permits the ready expression of munitions requirements in terms of any delivery system. This facilitates the apportionment of chemical fires and reduces the mechanics of fire planning. When chemical fire requests are to be sent to the Air Force or to the Navy, they would normally be expressed in terms of the weapon to be used or the amount of agent to be delivered on the target. Chapter 6 provides procedures for the calculation of munitions requirements for a variety of target conditions and agent effects. The results are not markedly different from those obtained using more involved methods.

34. Selection of Delivery Means

The selection of the optimum available delivery system capable of disseminating the selected agent on the target consists of the following steps:

a. Single out those systems that can deliver the selected agent, that are within range of the target, together with their characteristic impact patterns at that range, and that have the required accuracy.

b. If surprise effects are necessary to achieve the desired results, consider a maximum of 30 seconds of fire for the systems under consideration.

c. From the target size, weather and terrain conditions, and enemy protection level, determine the munitions requirements for desired effect (ch. 6).

d. For each of the selected systems above, determine the capability to fire the assigned mission, or a part of the assigned mission.

e. Consider limiting logistical and operational factors.

f. Compare *c* and *d* above and select a system(s) to recommend for employment.

35. Troop Safety and Contingency Requirements

a. General. Chemical agents produce a residual contamination hazard and a downwind

vapor hazard that must be considered in fire planning and target analysis. These hazards have tactical and political implications that must be weighed in the planning of chemical operations. Detailed methods for determination of troop safety distances are presented in chapter 7.

b. Tactical Consideration. Friendly troop locations must be considered in the planning of chemical fires since it is possible for toxic clouds to be carried into friendly positions. Cloud travel and concentration must be predicted so far as possible to allow either the maintaining of a minimum safe distance (MSD) for friendly troops or allow adequate warning and protection of friendly troops. Predicted cloud travel may require:

- (1) Change in location of impact area.
- (2) Use of a very accurate delivery system.
- (3) Use of particular agent-munitions combination.
- (4) Increase in the protection of friendly troops.
- (5) Withdrawal of friendly troops.
- (6) Postponement of chemical attacks pending more favorable meteorological conditions.
- (7) The use of other than chemical weapons.

c. Political Implications. The commander must be guided by established policy in making military decisions on the employment of chemical weapons that directly affect civilian populations.

36. Recommendation for the Employment of Chemical Weapons

Based on the chemical target analysis performed in the course of fire planning, recommendations are made for the employment of chemical weapons. As a minimum, the recommendations will include:

a. Location and type of targets recommended for attack with chemical agents.

b. The chemical agent to be used and the casualty effect.

c. The number of chemical munitions to be used (given in 155-mm equivalents, or number of specific munitions).

d. Time of attack.

e. Limitations on time for complete delivery.

f. Troop safety considerations to contain downwind hazard, protective measures to be taken by

friendly units, and coordinative measures required with adjacent units.

37. Integration of Chemical Fires Into the Overall Fire Support Plan

The integration of chemical fires into the overall fire support plan will entail coordination with all other fire support agencies involved in the operation and is the responsibility of the fire support coordinator. It will also require a continuous study of meteorological and target conditions, and should allow a degree of flexibility in agent-munition requirements to insure the effectiveness of the final attack.

38. Poststrike Analysis

a. General. In order to determine chemical attack effectiveness and to accumulate experience data for future chemical operations, it is necessary to conduct continual poststrike analyses of the effects of chemical fires.

b. Factors for Poststrike Analysis. After the attack of a target, the following information should be obtained, if possible, to aid in the determination of the effectiveness of chemical fires:

- (1) Number and type of casualties.
- (2) Number and conditions of personnel in the target area at the time of the chemical attack.
- (3) Agent effectiveness against different types of protection and types of positions.
- (4) Enemy countermeasures and their effectiveness.
- (5) Effect on enemy morale, efficiency, tactics, logistics, and communications.
- (6) Effect of the attack on friendly forces.
- (7) Area coverage and delivery system accuracy.
- (8) Residual hazard and downwind hazard.
- (9) Expenditure of chemical munitions if different from planned expenditures.
- (10) Conditions at the time of attack.

c. Sources of Poststrike Analysis Information. The sources of information for poststrike analysis are essentially the same as those used in procuring the initial target information (par. 30). Further sources are available if the area attacked has been occupied by friendly forces.

39. Target Analysis Format

To provide a logical sequence for the consideration of all the factors involved in the employment of chemical weapons, a particular target analysis format is recommended. In effect, it is a chemical estimate of the situation and follows the usual five-paragraph form of such an estimate. It provides for analysis and detailed comparison of

courses of action for the employment of chemical agents against enemy targets. The format outline for chemical target analysis is shown in appendix IV. Appendix V is an example of a recommended approach to the meteorological problems and the peculiarities of a particular area and the effects that these will have on the agent cloud behavior.

CHAPTER 6

COMPUTATIONS INVOLVING MUNITIONS REQUIREMENTS, AREA COVERAGE, AND PERCENT CASUALTIES

Section I. DETAILED METHOD

40. General

As previously discussed, the meteorological and terrain conditions greatly influence agent effects. The methods of computation presented here involve the use of specific information relating to these factors as they affect expenditure requirements, area coverage, and casualty predictions. The analyst should bear in mind that, although these methods are in general agreement with test information, they, like those for all other weapons systems, are based on statistical predictions and technical estimates and as such cannot be expected to provide great accuracy in specific situations.

41. Analysis Variables

a. In order to use this system of analysis, the analyst must know (or estimate):

- (1) Agent to be used.
- (2) Terrain and vegetation in the target area.
- (3) Temperature, temperature gradient, wind speed and direction, and precipitation in the target area at the proposed time of employment.
- (4) State of training of and protective equipment available to personnel in the target area.

b. Knowing the factors in *a* above and any two of the three variables—target area, percent casualties desired among unprotected personnel, and munitions requirements (in terms of number of 155-mm howitzer rounds)—the analyst can determine the third variable.

c. Delivery error is not considered in computation of munitions requirements nor is it used to establish probabilities of achieving the desired area coverage, since a suitable method for its consideration is yet to be developed.

d. In estimating the capability of division cannon artillery to deliver chemical agent on a target,

using maximum rates of fire, figure 9, the lack of time to shift and relay the guns limits area coverage capabilities. A rule of thumb for cannon artillery when these rates of fire are employed is: assign a 105-mm battery a target of no larger than 5 to 7 hectares; assign a 155-mm or 8-inch battery a target of no larger than 7 to 10 hectares. While cannon artillery may be capable of firing a weight of agent that will be theoretically adequate for an area, the problem of distribution will limit the actual area coverage. Normally, targets of larger size will be broken down into more than one battery fire mission. Otherwise, lower rates of fire will have to be used to allow time for shifting and relaying of guns.

e. When multiple bomblet or multiple rocket systems are employed, the impact pattern of the weapon and the casualty effect of the agent delivered must be considered to insure that the pattern is suitable for the target and that the desired casualty level will be achieved. This is accomplished through the following process:

- (1) Determine the size and shape of the weapon impact pattern.
- (2) Determine if the impact pattern is suited to the target size and shape.
- (3) Determine the number of 155-mm chemical equivalents needed to give the desired effect on the target area.
- (4) Determine the number of weapons needed to give at least the required number of equivalents.
- (5) In the case of multiple bomblets, consider the height of release, since it affects the size of the area covered and the casualty level in that area.

42. Computation of Munitions Requirements

The five steps involved in the computation of munitions requirements are enumerated below

and are discussed in detail in subsequent paragraphs:

- a. Determination of target area.
- b. Determination of degree of protection available to the enemy and conversion of desired casualty level to a corresponding casualty level that would be produced for unprotected personnel (fig. 11). This determination is required only for other than surprise attack.
- c. Determination of the sum of effects components for the particular agent as related to the target conditions.
- d. Determination of munitions requirements in terms of 155-mm howitzer equivalents.
- e. Determination of unit capabilities to deliver munitions required.

43. Example Problems—Employment of GB and VX

The detailed procedures involved are discussed in their sequences as applied to the problems that follow. When factors considered for expenditures of munition offer a choice between two conditions, that condition yielding the higher expenditure will be used in computations.

a. Problem 1.

- (1) *Given*: A target requires 200 GB 155-mm chemical equivalents to achieve a desired level of casualties.
- (2) *Find*: The target requirements in rounds of each of the following munitions: 105-mm shell, 155-mm shell, 8-inch shell, and M55 rockets.
- (3) *Solution*: Multiply the appropriate conversion factors in figure 8 by 200. The results are as follows:

Equivalents required	Munitions	Conversion factor	Rounds required
200	105-mm shell.....	4	800
200	155-mm shell.....	1. 0	200
200	8-inch shell.....	. 41	82
200	M55 rocket.....	. 61	122

b. Problem 1 (continued).

- (1) *Given*: Time limit for firing is 30 seconds.
- (2) *Find*: The number of 105-mm batteries required; 155-mm batteries; 8-inch batteries; and M91 launcher batteries (M55 rockets).
- (3) *Solution*:
 - (a) Using the organization shown in column 5(e) of figure 5 and the rates of fire obtained from figure 9 construct the following table:

Weapon	Rate of fire, 30 sec	Wpn/Btry	Rd/Btry, 30 sec	Rd required from par. 43a(3)	No. Btry to give 200 equiv
105-mm how.....	6	6	36	800	23 (800/36)
155-mm how.....	3	6	18	200	11
8-inch how.....	1	4	4	82	21
M91 lchr (M55 rkt).....	45	12	540	122	¼ (3-lchr)

- (b) The figures given in the final column are requirements. Availability of artillery will usually preclude the firing of the mission by tube artillery. In this case the M91 launcher will be the weapon selected for employment.

c. Problem 2.

(1) *Given*:

- (a) Target size—250 hectares.
- (b) Target shape—circular.
- (c) Agent—GB.
- (d) Delivery means—M91 launcher (M55 rocket).

- (e) Range from delivery weapon to target—8,000 meters.
- (f) Target personnel—poorly trained troops with masks available.
- (g) Casualty level—30 percent; *surprise dosage is desired*.
- (h) Temperature gradient—inversion.
- (i) Wind speed—4 knots (approx 7 km/hr).
- (j) Temperature—50° F. (10° C.).
- (k) Terrain—open, level, with scattered vegetation.
- (l) Precipitation—none.

- (2) *Find*: The number of M91 rocket launchers required to attack this target.

(3) *Solution:*

- (a) Using figure 12, determine the total effects components to be 2.29 as follows:

Inversion.....	0.67
Wind speed, 7 km/hr.....	.50
Temperature, 50° F. (10° C.).....	.12
Open terrain.....	.30
No precipitation.....	.70
	2.29

- (b) Using nomogram, figure 13, place a hairline between 250 on the target area scale, and 30 on the percent casualties for unprotected personnel scale. Obtain a reference point 5.25 on the reference line.
- (c) Using figure 13, lay the hairline between the reference point 5.25 and 2.29 on the effects components scale; on the munitions expenditure scale, read 480 155-mm equivalents as the required munition expenditure.
- (d) Using figure 7, read the 155-mm equivalent of the M55 rocket as 1.6. Multiply 1.6 by 45, the total number of rounds in a ripple, and obtain 72 155-mm equivalents for one launcher.
- (e) Divide the total number of equivalents required, 480, by 72 and obtain a figure of 6.67 or 7 rocket launchers required to fire the mission.
- (f) As shown in figure 10, the impact pattern of a rocket launcher ripple from an M91 rocket launcher firing at a 8,000-meter range is almost circular. By superimposing the impact patterns of fires from seven launchers on the target area as shown in figure 6, the fires are distributed on the target as evenly as possible. The delivery error has not been considered (par. 41c).

d. *Problem 3.*

(1) *Given:*

- (a) Target—unprotected personnel.
(b) Target size—100 hectares.
(c) Target shape—circular.
(d) Agent—GB.
(e) Weapon—HONEST JOHN, M79 warhead.
(f) Wind speed—7 knots (approx 13 km/hr).

- (g) Temperature gradient—inversion.
(h) Temperature—86° F. (30° C.).
(i) Terrain—level, with intermittent woods.
(j) Precipitation—none.

- (2) *Find:* The optimum height of burst and casualty level expected.

(3) *Solution:*

- (a) From figure 3, FM 3-10A, select the height of burst as 2,000 meters, which gives a coverage of 113 hectares. This will assure coverage of the entire target, not considering delivery error.
- (b) Using figure 7, find the number of GB 155 chemical equivalents for the M79 warhead to be 60.
- (c) Using figure 12, determine the total effects components to be 3.02. Effects components are taken from the "GB (over 30-sec attack)" column of the figure since personnel are not protected.

Inversion.....	1.09
Wind speed, 13 km/hr.....	.70
Temperature, 86° F. (30° C.).....	.23
Open terrain.....	.30
No precipitation.....	.70
	3.02

- (d) Using figure 13, place a hairline between 60 on the munition expenditure scale and 3.02 on the effects components scale and establish a point (5.09) on the reference line.
- (e) Place the hairline between the reference point, 5.09, and the actual area coverage of the weapon, 113 hectares. Read 43 percent on the percent casualties scale. The size of the bomblet impact pattern is used rather than the actual target size, because the casualty effects pattern is larger than the target and will determine the casualty level within the impact area. If the target area were to be used in this situation, a higher casualty level would be read than actually would occur.

e. *Problem 4.*

(1) *Given:*

- (a) Target personnel—poorly trained troops with masks available.
(b) Target size—12 hectares.
(c) Target shape—rectangular (600 meters wide and 200 meters deep).

- (d) Agent—GB.
 - (e) Wind speed—5 knots (approx 9 km/hr).
 - (f) Temperature gradient—inversion.
 - (g) Temperature—60° F. (15.5° C.).
 - (h) Terrain—open, level, scattered vegetation.
 - (i) Precipitation—none.
 - (j) Time limitations on the delivery of agent on target—4 minutes or less.
 - (k) Casualty level desired—20 percent.
- (2) *Find*: Whether or not the mission can be fired with a 105-mm howitzer battery.
- (3) *Solution*:

- (a) Using figure 11, convert 20 percent casualties among protected personnel to the corresponding casualty level among unprotected personnel. This is 80 percent.
- (b) Using the "GB (over 30-sec attack)" column of figure 12, determine the total effects components to be 3.21 as follows:

Inversion.....	1. 09
Wind speed, 9 km/hr.....	1. 00
Temperature, 60° F. (15.5° C.).....	. 12
Open terrain.....	. 30
No precipitation.....	. 70
	3. 21

- (c) Using figure 13, place a hairline between 80 percent on the percent casualties scale and 12 hectares on the target area scale. On the point of intersection on the reference line, pivot the hairline until it intersects 3.21 on the effects components scale. On the munitions expenditure scale, read 12 as the number of 155-mm equivalents required.
- (d) To find the number of 105-mm rounds required to fire the mission, multiply 12 by a factor of four (obtain this factor from figure 8); the product is 48 rounds.
- (e) From figure 9, it is evident that one battery of six howitzers can easily fire the mission if no shift of fires is re-

quired. Since the target is twice as large as the dispersion pattern of a 105-mm battery (par. 31c(3)(c) and 41d), a shift of fires should be made. Figure 9 gives a time of 30 seconds for shifting of fires. On this basis the battery could fire twenty-four rounds on half the target in a little less than 30 seconds, take 30 seconds to shift fires, and have ample time to deliver the remaining twenty-four rounds on the other half of the target. The firing should be completed in less than 2 minutes.

f. Problem 5.

(1) *Given*:

- (a) Target size—200 hectares.
- (b) Target shape—elliptical.
- (c) Agent—VX.
- (d) Target personnel—well-trained troops with masks available.
- (e) Casualty level—30 percent.
- (f) Temperature gradient—lapse.
- (g) Temperature—70° F. (21° C.).
- (h) Wind speed—8 knots (approx 15 km/hr).
- (i) Terrain—open.
- (j) Precipitation—none.
- (k) Firing time limitation—complete fire within 10 minutes.
- (l) Weapons available—one 8-inch howitzer battery, two 155-mm howitzer batteries, one HONEST JOHN E19R2 warhead.

- (2) *Find*: Whether or not the mission can be fired with the weapons available, assuming the target to be within range of the weapons.

(3) *Solution*:

- (a) Using figure 9, determine the 10-minute rate of fire for the tube artillery weapons concerned. No rate of fire is required for the HONEST JOHN as only one is available. Determine the fire capability of the batteries available. Multiply the total round capability by the appropriate factor in figure 7.

Weapon	Rd, 10 min	Rd/Btry, 10 min	No. of Btry	Total Rd	VX 155-mm equiv, 10 min
155-mm how.....	30	180	2	360	360
8-inch how.....	10	40	1	40	87
HONEST JOHN.....	1	2	$\frac{1}{2}$	1	71
Total.....					518

- (b) Using figure 12, determine the effects components to be 2.59.
- (c) Using figure 13, place a hairline between 200 on the target area scale and 30 on the percent casualties scale. Establish a reference point, 5.14, on the reference line. Pivot the hairline on the reference line, placing the hairline on 2.59 on the effects components scale. Read 190 on the munitions expenditure scale.

- (d) The mission requires 190 155-mm equivalents and 518 equivalents are available; therefore, it can be fired. The required equivalents may be fired by the 155-mm batteries alone or by a combination of weapons, the only limiting factor being the capability of the cannon artillery to traverse to cover the portion of the target assigned.
- (e) One method of firing the mission would be to assign 70 hectares (fig. 3, FM

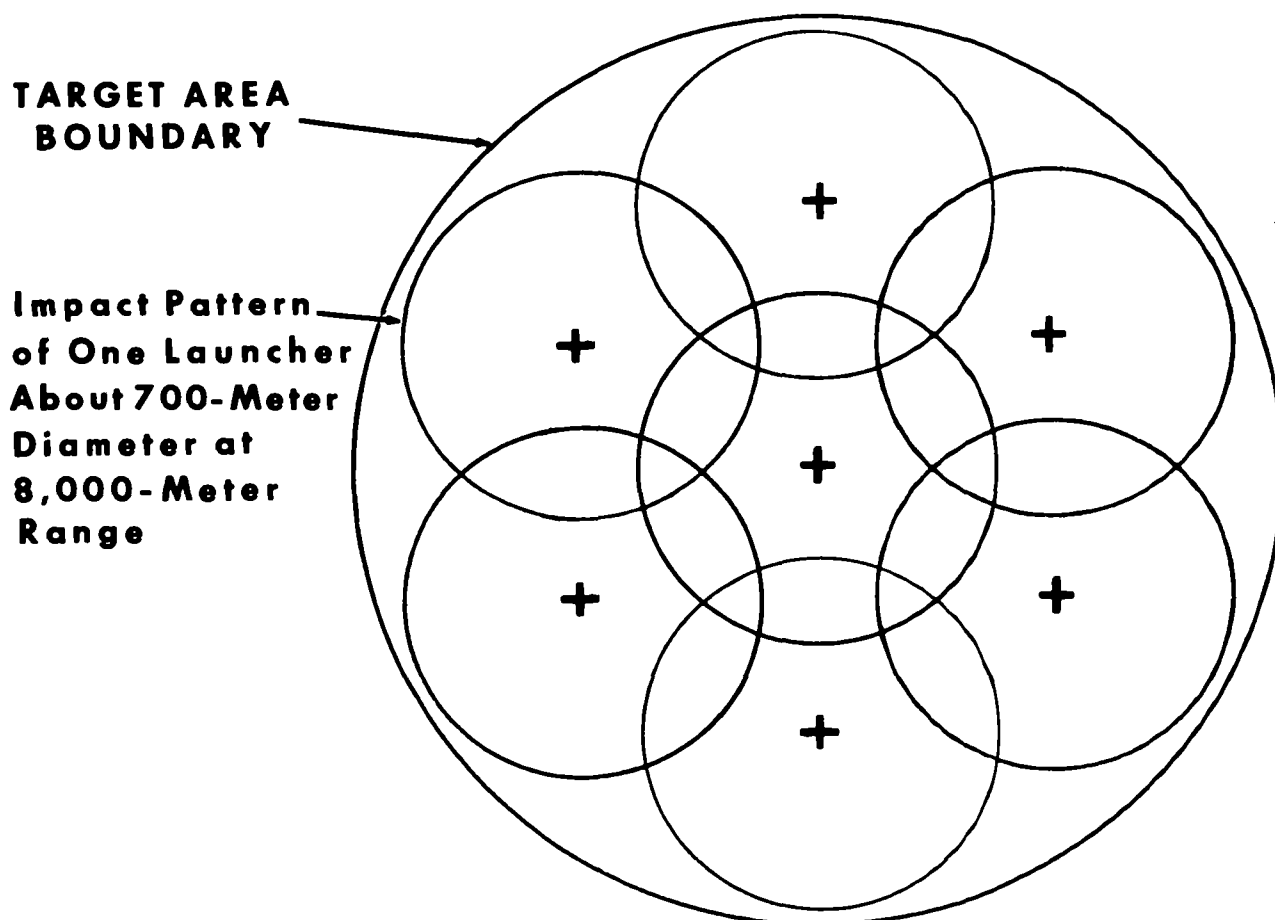


Figure 6. Application of rocket launcher ripple impact patterns to a target. (Seven M91 rocket launcher loads have been fired simultaneously on a 250-hectare target.)

Munition	Munition expressed in terms of 155-mm chemical equivalents		
	GB	VX	HD
155-mm Shell.....	1	1	1
105-mm Shell.....	0. 25		0. 28
8-inch Shell.....	2. 40	2. 17	
4.2-inch Mortar Shell.....			. 62
175-mm Shell.....	2. 1	2. 1	
M55 Rocket.....	1. 6	1. 6	
M79 Warhead—HONEST JOHN.....	60		
E19R2 Warhead—HONEST JOHN.....	71	71	
LITTLE JOHN.....	10	10	
SERGEANT.....	65	65	
M34A1 1000-lb Cluster.....	30		
MC1 750-lb Bomb.....	35		
5''/38 Gas Projectile (Navy).....	. 50		
5''/54 Gas Projectile (Navy).....	. 68		
5'' Gas Rocket (Navy).....	. 74		
500-lb Gas Bomb.....	17		
115-lb Gas Bomb (Navy).....			6. 2

Figure 7. Munitions expressed in terms of 155-mm chemical equivalents. (The figures given are an estimate of the number of 155-mm howitzer rounds required to give the same effect as one round of the specified munition. Dissemination efficiency has not been considered.)

3-10A; release height, 1,500 meters) to the HONEST JOHN, 50 hectares to each 155-mm battery, and 30 hectares to the 8-inch battery. This will allow the firing to be completed in less than 10 minutes. The HONEST JOHN would fire 71 equivalents, the

155-mm batteries would fire 8 volleys for a total of 96 equivalents, while the 8-inch battery would fire 4 volleys for a total of 35 equivalents. The actual amount of agent fired would be 202 equivalents. In this case cannon artillery will use area fire techniques to distribute the agent evenly on the target.

Munition	Conversion factor		
	GB	VX	HD
155-mm Shell.....	1	1	1
105-mm Shell.....	4		3. 6
8-inch Shell.....	0. 41	0. 45	
4.2-inch Mortar Shell.....			1. 61
175-mm Shell.....	. 48	. 48	
M55 Rocket.....	. 61	. 61	
M79 Warhead—HONEST JOHN.....	. 017		
E19R2 Warhead—HONEST JOHN.....	. 014	. 014	
LITTLE JOHN.....	. 098	. 098	
SERGEANT.....	. 016	. 016	
M34A1 1000-lb Cluster.....	. 033		
MC1 750-lb Bomb.....	. 029		
5''/38 Gas Projectile (Navy).....	2. 00		
5''/54 Gas Projectile (Navy).....	1. 46		
5'' Gas Rocket (Navy).....	1. 35		
500-lb Gas Bomb.....	. 059		
115-lb Gas Bomb (Navy).....			. 164

Figure 8. Conversion factors for converting 155-mm munitions to other munitions.

Weapon	Maximum rate (rounds)	Rates of fire for chemical fire missions without shifting or relaying of the piece (rounds)					Estimated time to shift fires
		30 sec	1 min	2 min	4 min	10 min	15 min
105-mm Howitzer.....	6		10	14	18	40	60
155-mm Howitzer.....	3		5	7	12	30	40
155-mm Gun.....	2		4	6	8	12	18
8-inch Howitzer.....	1		2	3	6	10	15
4.2-inch Mortar.....	10		16	30 (max)	50	80	105
M91 Launcher (M55 Rocket).....	45 (15 sec)	Launcher must relocate after firing each ripple.					

Figure 9. Approximate rates of fire for division cannon artillery, mortars, and multiple rockets firing chemical rounds. (Rates of fire for other weapons are given in figure 5.)

**DISPERSION PATTERN DATA FOR ONE M91 ROCKET
LAUNCHER RIPPLE (45 M55 ROCKETS)—**

<u>RANGE</u> <u>(meters)</u>	<u>WIDTH</u> <u>(meters)</u>	<u>DEPTH</u> <u>(meters)</u>	<u>AREA</u> <u>(hectares)</u>	<u>155-mm EQUIVALENTS</u> <u>GB</u>	<u>VX</u>
4,000	400	1,400	45	72	72
8,000	700	700	40	72	72
10,000	800	600	40	72	72

**REPRESENTATION OF THE DISPERSION PATTERN
DATA FOR ONE M91 ROCKET LAUNCHER RIPPLE—**

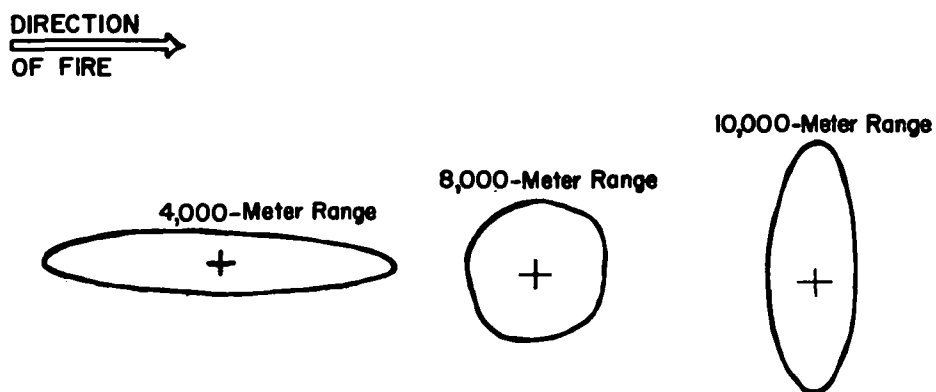


Figure 10. Dispersion patterns of the M91 rocket launcher ripple.

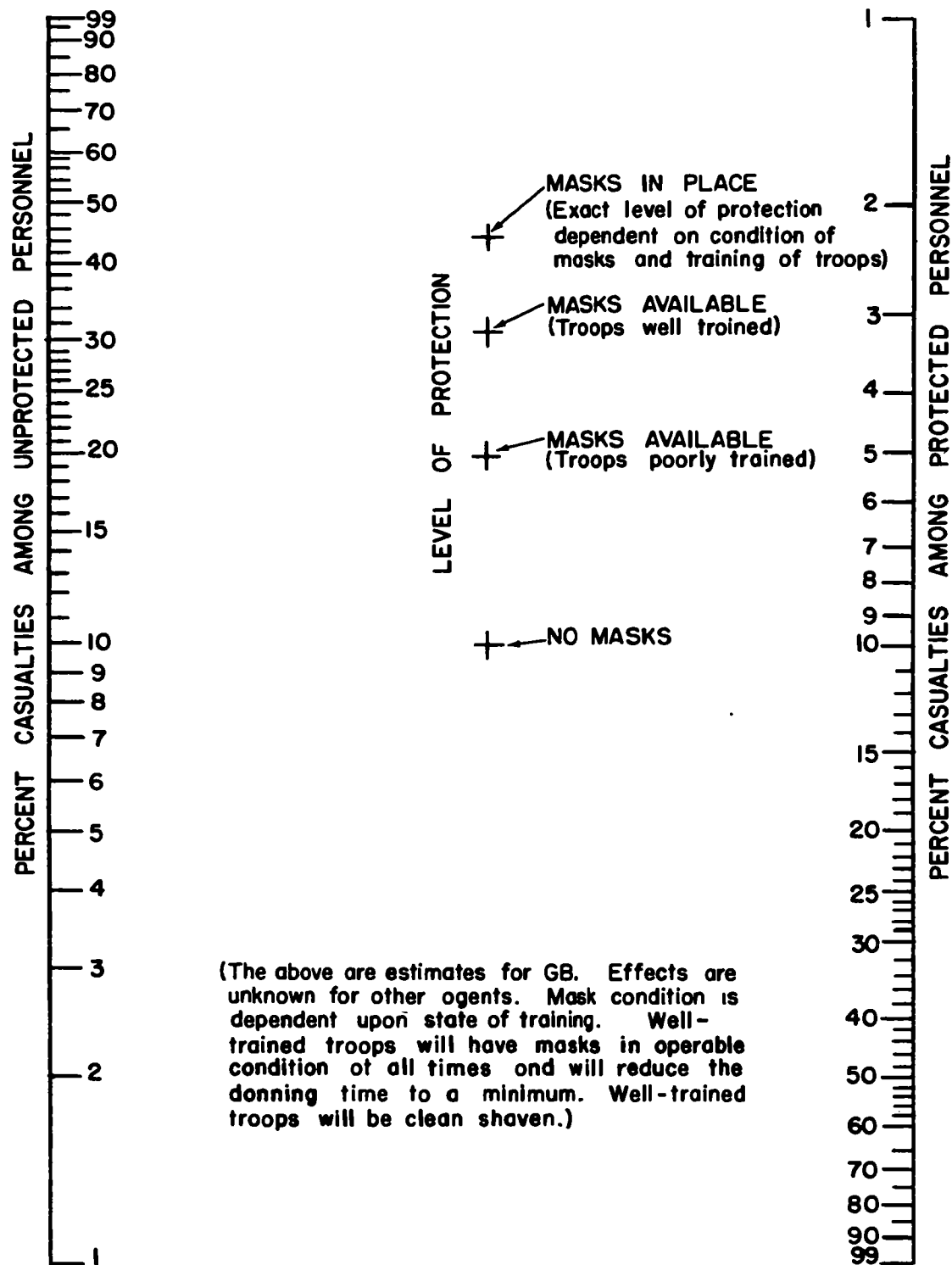


Figure 11. Nomogram for conversion of percent GB casualties for protection of personnel in the target area.

Meteorological and terrain conditions	Effects components			
	GB ¹ (surprise attack)	GB (over 30-sec attack)	VX	HD
1. Temperature Gradient				
Inversion.....	0. 67	1. 09	1. 89	0. 69
Neutral.....	. 57	. 69	1. 89	. 54
Lapse.....	. 30	. 09	1. 89	. 32
2. Wind Speed (km/hr)				
0 to 5.....	. 20	1. 30	0	. 87
6 to 10.....	. 50	1. 00	0	. 70
11 to 16.....	. 70	. 70	0	. 60
17 to 26.....	. 55	. 30	0	. 48
27 to 52.....	. 30	0	0	0
3. Temperature (° F.)				
a. 0 to 39 (—18° to 4° C.).....	0	0	0	-----
40 to 79 (5° to 26° C.).....	. 12	. 12	0	-----
80 and up (27° C. and up).....	. 23	. 23	0	-----
b. 30 to 49 (—1° to 9° C.).....	-----	-----	0	0
50 to 69 (10° to 21° C.).....	-----	-----	0	. 70
70 and up (22° C. and up).....	-----	-----	0	1. 00
4. Terrain				
Open, level, scattered vegetation.....	. 30	. 30	0	. 30
Rugged, mountainous.....	0	1 0	1 0	1 0
5. Precipitation				
None.....	. 70	. 70	. 70	0
Moderate rain.....	0	1 0	1 0	1 0

¹ Estimated.

² Tentative figures not yet verified.

Figure 12. Effects components.

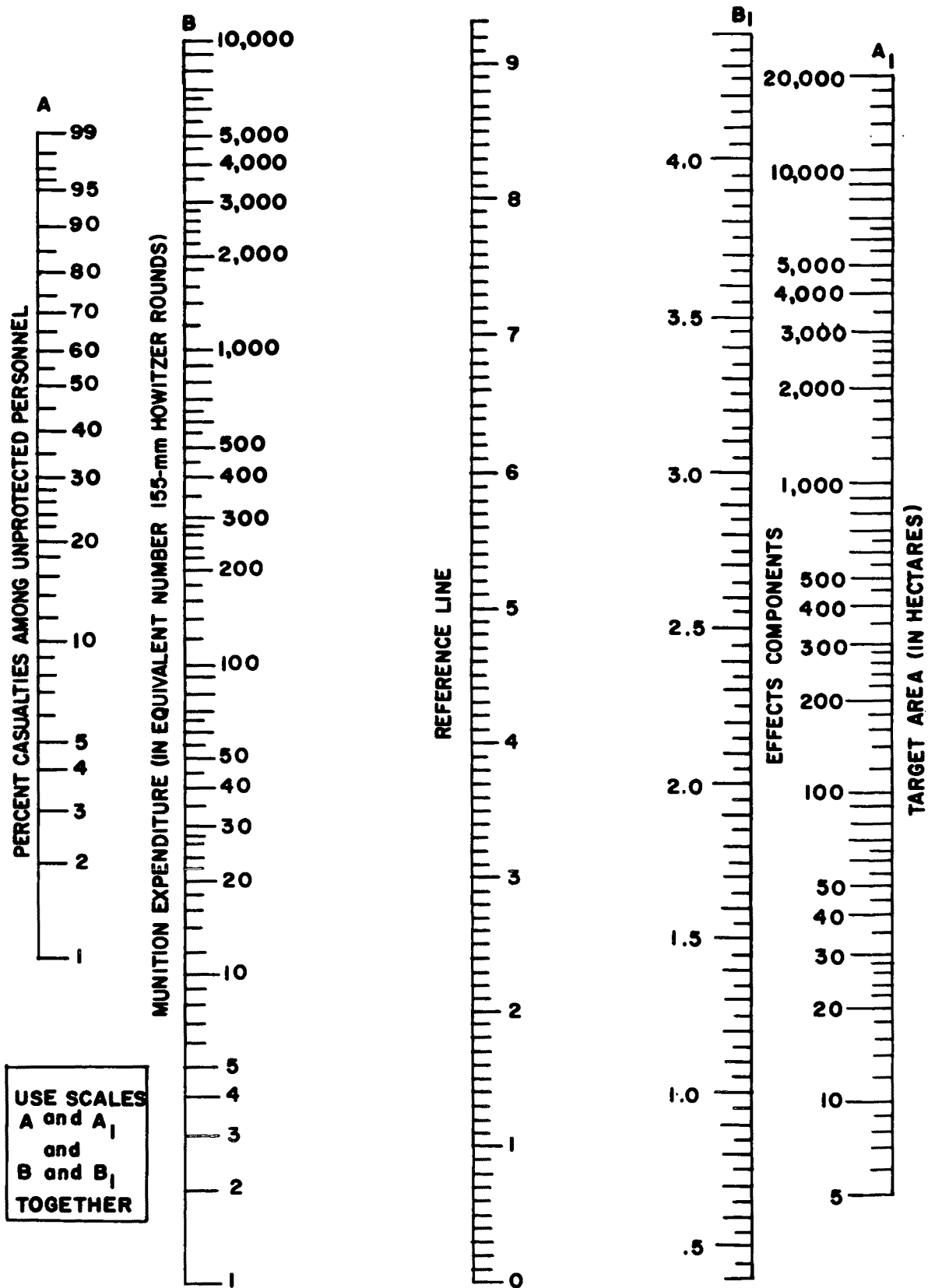


Figure 13. Target area, casualty level, munitions requirement nomogram.

Section II. RAPID METHOD

44. General

The rapid method of target analysis is based on the same rationale as the detailed method. In this method a chemical munitions requirement calculator (GTA 3-7-4) is used to obtain the number of chemical rounds required to engage a target.

45. Description, Use, and Limitations of the Chemical Munitions Requirement Calculator (GTA 3-7-4)

a. Description. The calculator consists of seven concentric wheels which when properly alined will show through window openings in the outer wheels the number of 155-mm equivalents required for a given target. Directions for use of the calculator are contained on one of the outer wheels. The other outer wheel contains a table A, "Effect Components (E_c)," patterned after figure 12, and table B, "Conversion Factor," patterned after figure 8.

b. Use. The use of the calculator is illustrated in the following example:

(1) *Given:*

- (a) Target—Troops unprotected.
- (b) Target size—30 hectares.
- (c) Agent—GB.
- (d) Wind speed—5 knots (approx 9 km/hr).
- (e) Temperature gradient—inversion.
- (f) Temperature—60° F. (15.5° C.).
- (g) Terrain—open, level, scattered vegetation.
- (h) Precipitation—none.
- (i) Casualty level desired—50 percent.

(2) *Find:* The munition requirements to produce the desired effects on the target.

(3) *Solution:* The sum of the effects components (E_c) from "GB over 30-second attack" column of table A is 3.21. This

sum falls within the E_c range 3.2 to 3.6, which indicates that the wheel so designated should be used.

- (a) To expose the readings on the large wheel, aline the tick marks of the other three wheels. Holding the wheels on this alinement, rotate the large wheel until 30 appears in the "size of target" window. The E_c value obtained (3.21) is closest to the window value of sum of effects components E_c 3.2.
- (b) Under the window E_c value of 3.2 and opposite 50 percent casualties, read 14 as the number of 155-mm equivalents required for a 30-hectare target under the given conditions.
- (c) Using table B, 14, the number of 155-mm equivalents, can be converted to any of the given munitions or a combination of these munitions.
- (d) If the target personnel had protection available, the following factors would be applied to the percent casualties for unprotected personnel:

Level of protection	Degradation factors
Masks in place.....	0.05
Masks available, troops well trained.....	.10
Masks available, troops poorly trained.....	.25

c. Limitations. The major limitations of this calculator are as follows:

- (1) VX values are not given. (VX values are given in figures 12 and 8.)
- (2) The number of weapons given in table B is limited.
- (3) Munition requirements can be computed only for 30 and 50 percent casualty levels among unprotected personnel.

CHAPTER 7

TROOP SAFETY

Section I. GENERAL

46. Introduction

a. The analysis of a potential chemical target includes a careful evaluation of hazards to friendly troops. These hazards include those within the target area itself, those created downwind of the target area, and those caused by inaccuracies in the delivery means. Troop safety considerations may preclude the employment of chemical weapons or may influence the selection of agent, delivery system, location of point of impact, or planned time of attack.

b. Even though the employment of chemical weapons may not present an immediate hazard to friendly troops, the following factors must be considered:

- (1) Chemical agents may interfere with continued or future operations.
- (2) A certain margin of safety may be desired for noncombatant populations or friendly forces in enemy territory.

c. Calculations of troops safety are based on estimates produced from consideration of all available information and as such may not be precise or representative of the actual results obtained in specific instances. For offensive considerations, calculations of expenditures and dosage levels are based on producing the desired level of casualties in the target area and assume a conservative estimation of conditions for the desired effect. On the other hand, for safety considerations, optimum conditions and minimum of threshold dosages must be assumed. The methods for calculation of safety distances are conservative to the extent that there is a high degree of assurance that predicted downwind effects will not be exceeded. Friendly units located near the perimeter of the area calculated to be affected must be forewarned and prepared to adopt protective measures. When the degree of risk to friendly troops is determined to be significant, decision for employment of

chemical agents should be based on the urgency of the situation, the importance of the target, and the choice of alternate weapons. Under such circumstances, protective measures to be taken by friendly units will be directed.

47. Persistency Hazard

a. Personnel in an area contaminated with toxic chemicals are exposed to a hazard that varies in time according to the amount and type of agent disseminated, existing meteorological conditions, and terrain conditions. Friendly troops should not enter a contaminated area unless they use protective equipment, the area has been decontaminated, or sufficient time has elapsed to permit weathering of the contamination to safe limits. It is recognized that the urgency of the tactical situation may override these troop safety considerations.

b. While GB is normally disseminated in the aerosol form for nonpersistent effect, some liquid GB will remain in chemical shell craters for extended periods of time, varying from 6 hours to days depending on weather conditions and type of munition. Craters should be avoided by friendly troops until tests with the detector kit prove the absence of hazardous contamination.

c. VX, an agent of very low volatility, presents a persistent hazard that ranges from several hours to several days depending on the nature of the terrain, the local climatic conditions, and the type of munition. It is more persistent in dry soil than in damp soil.

d. When mustard (HD) is disseminated as a liquid, it contaminates terrain and materiel, creating a liquid contact hazard as well as a vapor hazard. Ground contamination, such as shell craters, presents a hazard to personnel for a time varying from 36 hours to several days (fig. 3). A limited vapor hazard will exist where HD is employed in the liquid form.

48. Downwind Hazard

Toxic chemical agents present a vapor or an aerosol hazard to troops for a predictable distance downwind of the chemical munition impact area. The method to compute the maximum downwind distance to which a stated degree of hazard may extend is given in paragraph 55.

49. Delivery System Error

For most weapons systems there is a probable error in the accuracy of delivery. When chemical agents are to be delivered close to friendly troop dispositions, this error must be considered in order to prevent the inadvertent delivery of a chemical agent on friendly troops. This degree of expected error is generally small for tube artillery but of significant size for rockets and missiles. Delivery error is obtained from delivery unit or appropriate firing tables.

50. Possible Course of Action if Risk Criteria Are Exceeded in a Particular Chemical Attack

When the distance from the target to friendly dispositions is less than the minimum safe distance required, one or more of the following courses of action are sometimes possible.

- a. Change the location of the center of impact.
- b. Use a more accurate delivery system.
- c. Use a different agent.
- d. Increase protection.
- e. Fire under more suitable meteorological conditions.
- f. Withdraw troops.
- g. Do not use chemical agents.

51. Degrees of Risk and Levels of Protection

a. For friendly troops *not wearing protective masks* there are three degrees of risk that the commander will consider in formulating his guidance for the planned operation. These degrees of risk are expressed in terms of dosages which influence unit effectiveness.

- (1) *Negligible risk.* Troops are completely safe though there may be minor symptoms of chemical agent effect. The combat effectiveness of units is not im-

paired. Vapor dosages for negligible risk are:

GB—1 to 5 milligram-minutes per cubic meter (mg-min/m³)

HD—1 to 25 mg-min/m³

VX—*

- (2) *Moderate risk.* A few troops may require evacuation because of chemical agent effects. There may be very slight reduction in unit combat effectiveness, but units will be able to perform assigned missions. Vapor dosages for moderate risk are:

GB—6 to 10 mg-min/m³

HD—26 to 50 mg-min/m³

VX—*

- (3) *Emergency risk.* There will be some casualties that will require evacuation or treatment. The combat effectiveness of the unit may be significantly reduced. An emergency risk should be accepted only when absolutely necessary. Vapor dosages for emergency risk are:

GB—11 to 15 mg-min/m³

HD—51 to 100 mg-min/m³

VX—*

b. The vulnerability of friendly troops to chemical agents will vary with the degree of protection afforded. The protective mask, in proper condition and properly worn, will offer almost complete protection against eye and inhalation effects of all known agents. Defense against skin effects of chemical agents will vary with overhead cover and the type and amount of protective clothing worn by troops. For purposes of determining troop safety requirements, levels of protection are classified as:

- (1) *Protected.* Troops are equipped with protective masks, are warned, and are wearing protective clothing (AR 700-62, TM 3-304).
- (2) *Masks only.* Troops are equipped with protective masks and are warned, but are not equipped with protective clothing.
- (3) *Unprotected.* Troops have no masks available and are not wearing protective clothing.

*Will be added at a later date.

Section II. TROOP SAFETY CALCULATIONS

52. General

This section provides commanders and staff officers with procedures for:

- a. Determining the minimum safe distance for friendly troop dispositions close to the target area.
- b. Determining the time after the chemical attack at which unprotected friendly troops can enter or cross areas at specified distances downwind of the target area.
- c. Forecasting the area to be affected by hazardous vapor dosages.
- d. Alerting friendly units concerned.

53. Minimum Safe Distance

To determine the minimum safe distance (MSD) from the center of impact for friendly troops located close to the target area, the following formula is used:

$$\text{MSD} = \frac{1}{2}D + d_b,$$

where D is the maximum diameter of the impact area, and d_b is the buffer distance. For a very high assurance of troop safety, d_b is computed as follows:

- a. For missiles and air-delivered weapons, the d_b is 2 CEP (circular error probable). The CEP for these weapons will be obtained from the delivery unit or appropriate firing table.
- b. For tube artillery and rockets, the probable error will be obtained from the delivery unit. The d_b for these weapons is 3.5 times the largest error plus 200 meters.

54. Safe Entry Time Into an Area Downwind of the Target Area

a. In considering the safe entry time for unmasked personnel into an area downwind of the target (when the entry area is within the downwind hazardous distance), the time of cloud arrival to the entry area and time of cloud clearance of the entry area must be determined. In computing these times, the following factors must be considered:

- (1) The time the chemical fire mission is completed.
- (2) The chemical agent cloud measurement parallel to the wind direction.
- (3) Wind speed and direction.
- (4) Drag effects (the retarding action on the movement of the agent cloud caused by

irregularities of terrain, slight changes in wind speed and direction, presence of vegetation, and other factors).

- b. The calculated time for chemical cloud clearance of the entry area is based on the time the firing is completed and the time it will take the tail of the cloud to travel the downwind distance to clear the entry area. Since drag effects cannot be precisely measured, a safety factor of 10 minutes is added to time scheduled for cloud clearance of the entry area.

55. Computation of Maximum Downwind Distance

a. Nomogram Method.

- (1) The maximum downwind distance (MDD) to which a given dosage may extend is computed by the use of nomograms (figs. 14 and 15). The wind speed in kilometers per hour, the dosage is milligram-minutes per cubic meter, the source length in kilometers, the source strength in kilograms per meter, and the temperature gradient must be known in order for the nomograms to be used. The forecast of meteorological data is obtained from the intelligence staff section. The dosage used will be determined by the degree of risk as prescribed or implied by the commander. Normally, the negligible risk dosage (par. 51a) will be used. The source length is the length in kilometers of the crosswind axis of the impact area. The effective source strength is equal to the total weight in kilograms of agent delivered on target, divided by the source length in meters. The total weight in kilograms of agent delivered on the target is computed by multiplying the number of munitions delivered on target by the weight of agent per munition in kilograms as given in figure 5.

- (2) Example problem for computation of maximum downwind distance.

(a) *Given:* Target area—40 hectares, rectangular in shape, approximately 800 x 500 meters.

Wind speed—7.5 knots (approx 14 km/hr).

DOWNWIND DISTANCE NOMOGRAM I



Figure 14. Downwind distance nomogram I.

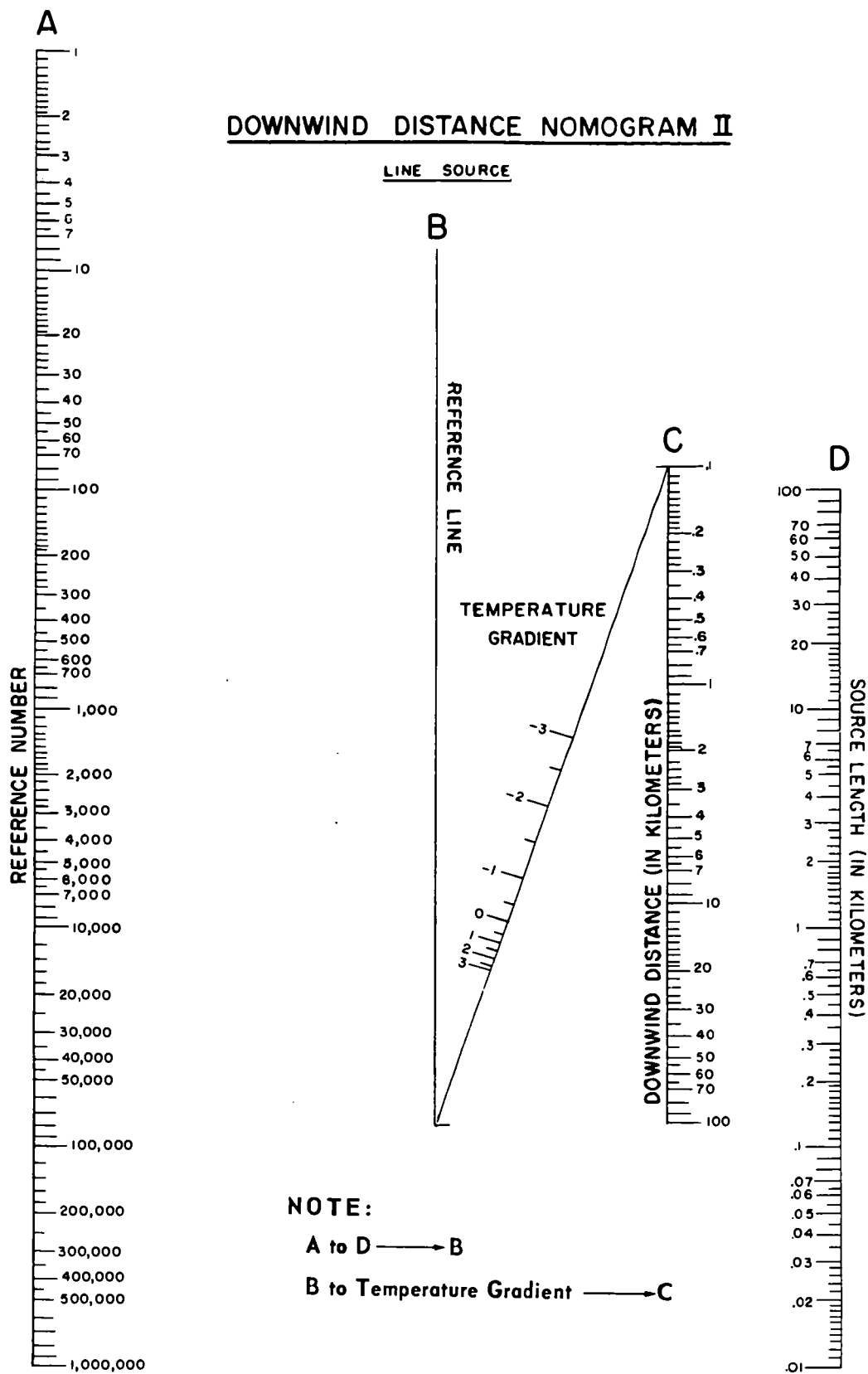


Figure 15. Downwind distance nomogram II.

Wind direction—perpendicular to the 800-meter axis of the target.
 Source length—800 meters (.8 km).
 Agent and munition to be used—GB, 68 155-mm rounds.
 Temperature gradient—0 (neutral).

(b) *Find:* Maximum downwind distance to which a vapor cloud of 5 mg-min/m³ dosage will extend.

(c) *Solution:*

1. Using the downwind distance nomogram I (fig. 14), connect with a hairline 5 mg-min/m³ on the dosage scale with 14 km/hr on the wind

- speed scale. Note the point of intersection on reference line I.
2. Pivot the hairline on the point of intersection on reference line I and connect with .8 km on the source length scale. Note the point of intersection on reference line II.
3. Pivot the hairline on the point of intersection on reference line II and connect with 0 (neutral) on the temperature gradient scale. Note the point of intersection on reference line III.
4. Determine the effective source strength of the agent by the following formula:

$$\text{Effective source strength} = \frac{\text{No. of rounds} \times \text{kg of agent/round}}{\text{Source length (length in meters of the crosswind axis of target)}}$$

$$= \frac{68 \times 2.95}{800}$$

Effective source strength = 0.25 kg/m.

5. Connect with the hairline the point of intersection on reference line III with 0.25 kg/m on the source strength scale. This line intersects the reference number scale at 17,000.
6. Turn to downwind distance nomogram II, figure 15. Connect with the hairline the value of 17,000 on the reference number scale with .8 km on the source length scale. Note the point of intersection on the reference line.
7. Pivot the hairline on the point of intersection on the reference line and connect with 0 on the temperature gradient scale. Read a value of 4.5 kilometers on the downwind distance scale.

(d) Answer: 4.5 kilometers is the maximum downwind distance to which a vapor cloud of 5 mg-min/m³ dosage will extend under the given conditions.

b. *Slide Rule Method.*

- (1) A slide rule for calculation of downwind distance for a given set of conditions is in the back cover.
- (2) The slide rule requires the same input data as is used in the nomogram method

and its operation is illustrated in the problem that follows.

- (3) Compute the downwind distance to a dosage level of 5 mg-min/m³ given the following conditions:

Length of source..... 800 meters
 Source strength..... .25 kg/m
 Wind speed..... 7.5 knots (approx 14 km/hr)
 Temperature gradient... neutral (0)

- (a) Aline 5 mg-min/m³ on the D scale with 800 meters on the L scale.
- (b) Allowing the center wheel to turn with the middle wheel so that the two wheels remain fixed in position with respect to each other, aline .25 kg/m on the P scale with 14 km/hr on the U scale.
- (c) Read 10.3 on scale M opposite the neutral (0) point on the temperature gradient (ΔTG) scale.
- (d) On the reverse side of the slide rule, aline 800 meters on scale L with 10.3 on the M scale.
- (e) Holding the alinement, read about 4.6 kilometers where the downwind distance scale is intersected by the neutral (0) curve.

56. The Downwind Vapor Cloud Template

The downwind vapor cloud template (located inside back cover) is a device that will permit the fire planner to portray the envelope of the chemical cloud. It is a rectangular piece of acetate provided with a scaled grid design of 1:50,000 or 1:100,000. The parallel lines in the template are scaled to 1,000-meter intervals. The point in the template where the two accentuated lines cross denotes the center of the impact pattern.

57. Use of the Template

a. The following information is needed for plotting the vapor cloud envelope on the template:

- (1) The outline of the expected distribution pattern of impacts.
- (2) The maximum downwind distance (MDD) of the vapor cloud. A method for computing MDD was described in paragraph 55. A rule of thumb method for estimating the cloud width is given in *b* below.
- (3) Information of terrain conditions and vegetation in and downwind of the target area. Because of the many different terrain conditions and types of vegetation found in the battlefield, it is impossible to prescribe a standard method for determining the effects that these two factors will have in the configuration of the downwind agent cloud. Chapter 3

should be reviewed for consideration of these effects.

b. Once the data are determined, the following steps are taken to portray the envelope on the downwind vapor cloud template:

- (1) Determine the length in meters of the crosswind axis of the expected dispersion pattern (fig. 16).
- (2) To one-half of the length of this axis, add the buffer distance for the weapon to be used as shown in paragraph 53. With the resultant figure as the radius, draw a circle using the intersection of the two accentuated lines on the template as the center (step 2, fig. 17).
- (3) Determine the maximum downwind distance to the acceptable dosage level (par. 55). Draw a line on the template perpendicular to the wind direction at the maximum downwind distance (step 3, fig. 17).
- (4) Draw two reference lines tangent to the circle and parallel to the wind direction (step 4, fig. 17).
- (5) From the points of tangency of the reference lines, draw diverging lines at 6-degree angles. Extend these lines to the MW line (step 5, fig. 17). If for planning purposes the analyst desires to include possible shifts in wind direction, the angle used is 20 degrees.

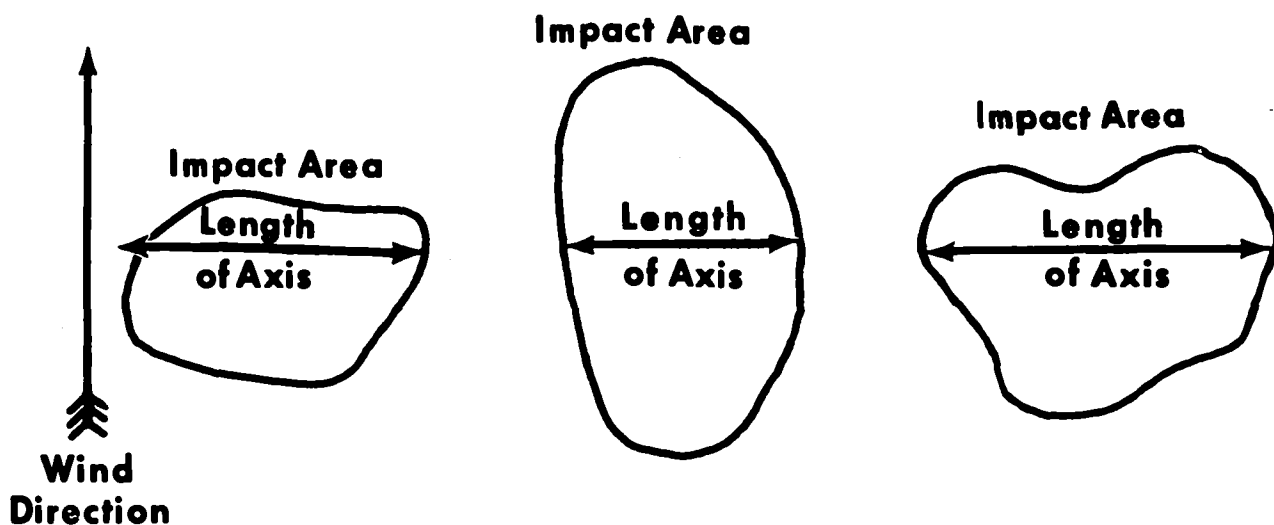
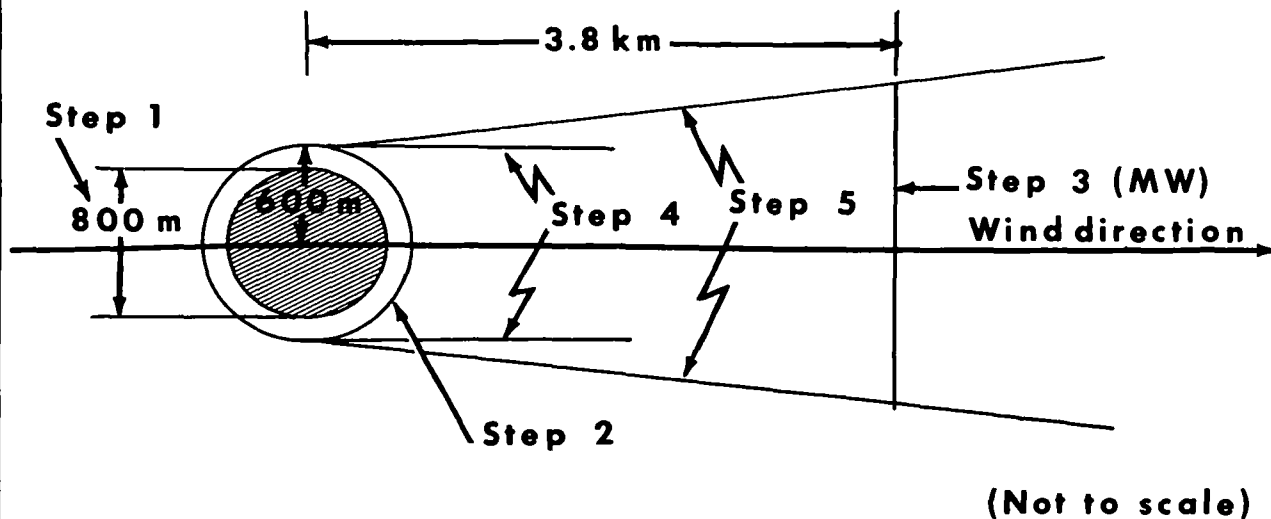


Figure 16. Examples of crosswind axes.



Step 1. Maximum diameter of impact area was determined to be 800 meters.

Step 2. The d_b for this weapon was found to be 200 meters.

$$\frac{\text{Length of axis} + d_b}{2} = \text{radius of circle.}$$

$$\frac{800 + 200}{2} = 600 \text{ meters.}$$

Draw circle with a radius of 600 meters.

Step 3. Maximum downwind distance was determined to be 3.8 kilometers. A line is drawn perpendicular to the wind direction and 3.8 kilometers downwind from the center of impact (MW).

Step 4. Draw reference lines.

Step 5. Draw lines at 6-degree angle to reference lines and extend lines to the maximum downwind width line (MW). This allows for lateral diffusion of cloud based on flat terrain. (Possible shifts in wind direction are not included. If such shifts are to be considered, a 20-degree angle should be used in this step.)

Figure 17. Example for drawing a vapor cloud envelope.

58. Dissemination of Prediction Message on Downwind Vapor Hazard

a. Information of the predicted downwind vapor hazard for a planned chemical attack is disseminated in advance in the form of a prediction message. The format for the message will be a series of 5 to 8 digit groups preceded by the phrase "Downwind Vapor Hazard Prediction Message" as follows:

EXAMPLE OF DOWNWIND VAPOR HAZARD PREDICTION MESSAGE (DVHPM)

DELTA	PQ825467	(coordinates of preselected center of impact pattern).
VICTOR	250800	(25 is date; 0800 is time of attack).
HOTEL	303800	(3 is agent code*; 03800 is MDD in meters).
PAPA	6002000	(600 is radius of dispersion pattern in meters; 2000 is maximum width of cloud in meters at MDD).
MIKE	14180	(14 is wind speed in km/hr; 180 is direction from which wind blows in degrees).

*The number 3 is given as an agent code example only.

b. Upon receipt of the downwind vapor hazard prediction message, the recipient will plot to scale the predicted vapor cloud envelope on a piece of overlay paper by taking the following steps:

- (1) Select a point representing the center of impact and draw a circle with a radius of the dispersion pattern (600).
- (2) From the center of impact, draw a reference line to represent the length of the maximum downwind distance hazard (03800).
- (3) At the maximum downwind distance point, draw a perpendicular line to the reference line to show the maximum width of the cloud at the MDD (2000). The reference line intersects the width line at its center.
- (4) The last step to complete the predicted vapor cloud envelope is to draw two lines, each line constructed from each end of maximum width line and extending until it is tangent to the circle of the dispersion pattern.

c. The predicted vapor cloud envelope as plotted by the recipient will be oriented on the situation map, using the coordinates of the planned center of impact (PQ 825467) and the predicted wind direction (180°). By a study of the area covered by the predicted vapor cloud envelope and the expected disposition of his unit at the time of the chemical attack, the commander should be able to estimate the effects that the attack will have on his unit and to determine the protective measures that he should initiate.

d. Two of the most important variables affecting the area covered by a vapor cloud are the wind direction at the time of the attack and the center of impact of the dispersion pattern. Immediately upon completion of the chemical attack, a flash message will be forwarded to all units concerned containing a reference to the pertinent downwind vapor hazard prediction message, the coordinates of the actual center of impact (DELTA), and the prevailing wind direction (MIKE) at the time the target was attacked. With this information, the recipient will be able to reorient the vapor cloud envelope readily and make a reassessment of the effects that his unit will receive.

CHAPTER 8

COMMAND AND STAFF ACTIONS

Section I. PLANNING

59. General

Most of the planning for the tactical employment of chemical weapons is done at division level since:

a. The majority of the delivery means are under the command of, or available to, the division headquarters.

b. The division is normally the lowest echelon that has the ability to properly coordinate chemical agent attacks.

60. The Chemical, Biological, and Radiological Element (CBRE)

The CBRE (CBRC at division level) is that part of the Chemical Special Staff section which performs the primary functions of detailed planning of chemical and biological operations and the evaluation of CBR contamination data. The CBRE is supervised by the chemical officer and is physically located in or adjacent to the FSCE (FSCC at division level). Its functions in chemical operations are:

a. Detailed planning of chemical operations.

b. Coordination of chemical plans with FSCE.

c. Supervision and coordination of chemical surveys.

d. Evaluation and dissemination of chemical contamination data.

61. Commander's Responsibilities

When considering the employment of chemical weapons, the commander must:

a. Decide on the employment of chemical weapons.

b. State generally the results desired from a chemical attack.

c. Prescribe troop safety requirements.

d. Provide for an exploiting force when appropriate.

e. Establish limitations on the use of chemical agents against civilians.

62. Staff Responsibilities

Based upon the commander's planning guidance, each staff agency prepares an estimate of the situation. These estimates are coordinated among all staff sections, and, in the case of chemical operations, primary coordination is effected between G2, G3, FSC, and the chemical officer.

a. Chemical Officer.

(1) Advises G3 and the fire support coordinator on the use of chemical and biological agents in support of the operation, and recommends to G3 on the use of chemical troops.

(2) Makes target analyses to determine enemy vulnerability, the type and amount of agent required, the extent and duration of contamination, and the best delivery means for attack of each target.

(3) Prepares the CBR plan appendix to the fire support plan annex to the operations plan.

(4) Performs target analysis of target areas to be attacked using CB munitions to include predicted effects and submits to the fire support coordinator.

(5) Advises preventive measures to be taken by troops entering contaminated areas.

b. Other Staff Officers. The staff functions of other staff sections relating to chemical operations are given in figure 21, FM 101-5.

63. Commander's Estimate, Decision, and Concept

Staff estimates, including the target analysis, form the basis for a commander's estimate. The target analysis may indicate that certain requirements stated or implied by the commander in his planning guidance cannot be met or are at best marginal as to accomplishment. The commander

may then choose to modify or revise these requirements. This revision of requirements includes:

- a. Acceptance of a reduced casualty level in enemy troops.
- b. Acceptance of a higher degree of risk for friendly troops.
- c. Change of time of attack.
- d. Movement of friendly troop units.
- e. Displacement of agent release point.
- f. Use of a different agent or delivery means.
- g. Improvement of troop protection criteria.
- h. Decision not to employ a chemical agent in a particular situation.

64. Staff Planning Phase

After receipt of the decision of the commander's concept of the operation, the staff prepares necessary plans to implement the decision. Alternate plans are prepared to cover contingencies such as unusual changes in meteorological conditions. In event the commander's decision differs from the courses of action developed by G3, or he changes initial contingent requirements, additional target analyses are required to insure that chemical plans support the commander's decision and

concept of operation. These analyses are then incorporated into the continuing staff estimates and into the tactical plan.

65. Execution Phase

The culmination of the staff action will be the issuance of an order and supervision of its execution. During the execution phase, the following staff actions are required:

- a. Revision of effects estimates and troop safety considerations to exploit unforeseen favorable developments or to protect against unfavorable ones.
- b. Rapid analysis of targets of opportunity arising as a result of the execution of the chemical plan in order to take full advantage of tactical opportunities.

66. Poststrike Analysis

The intelligence officer, in coordination with the chemical officer, will gather and interpret information concerning the chemical attack after its completion. An analysis of this information (poststrike analysis) will be prepared and distributed by the intelligence officer.

Section II. CHEMICAL AMMUNITION SUPPLY

67. Ammunition Logistic Responsibility

Both the Ordnance Corps and the Chemical Corps have certain logistical responsibilities in regard to chemical ammunition.

a. Within CONUS, the Chemical Corps has logistical responsibility for all items as indicated in figure 18, or assigned by Army regulations of the 701-series. This includes complete responsibility from research and development through depot storage, issue, and maintenance. The Ordnance Corps has complete responsibility for all other ammunition items including chemical-filled artillery cannon ammunition except that the chemical filling is the responsibility of the Chemical Corps.

b. In the theater of operations the only change to this assignment of logistical responsibility is that chemical-filled warheads for missiles (chemical-filled special ammunition) will normally go into the ordnance supply channels at the point of entry into the theater. This is necessary to preserve the integrity of the "Complete Round" concept since the Ordnance Corps controls the missile body unit. The Chemical Corps will furnish technical assistance as required from TOE teams of the 3-500 series. A flow chart for

FSC Class	Ammunition type
1305	Ammunition through 30-mm (Ordnance Corps responsibility).
1310	Ammunition over 30-mm up to 75-mm (Ordnance Corps responsibility).
1315	Ammunition 75-mm through 125-mm (Ordnance Corps responsibility).
1320 ¹	Ammunition over 125-mm (Ordnance Corps responsibility).
1325	Bombs. (See AR 701-1325. All bombs are Ordnance Corps responsibility except bombs, gas, incendiary, smoke, and components.)
1330	Grenade, hand. (All Ordnance Corps responsibility except grenade, gas, incendiary, smoke, WP; and grenade, hand, smoke, colored. See AR 701-1330 for detailed breakdown.)
1336 ¹	Guided missile warheads and explosive components. (All Ordnance Corps responsibility except warhead, guided missile chemical agent, which is Chemical.)
1340 ¹	Rockets and rocket ammunition. (All Ordnance Corps responsibility except rocket, gas, and rocket, incendiary, which are Chemical.)
1345	Land mines. (All Ordnance Corps responsibility except mine, chemical agent, which is Chemical.)

¹ Some of which are chemical-filled special ammunition.

Figure 18. Logistics assignment for ammunition (Federal supply classification class 1300) (AR 701-series).

chemical-filled special ammunition is contained in figure 19 and a similar chart for chemical conventional ammunition is shown in figure 20.

68. Chemical Ammunition Supply in a Theater

The theater commander is responsible for the requisition, receipt, storage, distribution, surveillance, maintenance, renovation, and disposal of all

ammunition within the theater. As discussed in paragraph 67, the theater ordnance and chemical officers are responsible for the staff supervision of these functions as they pertain to chemical ammunition. When a communication zone is established, these functions are performed by the commander of the theater army logistical command.

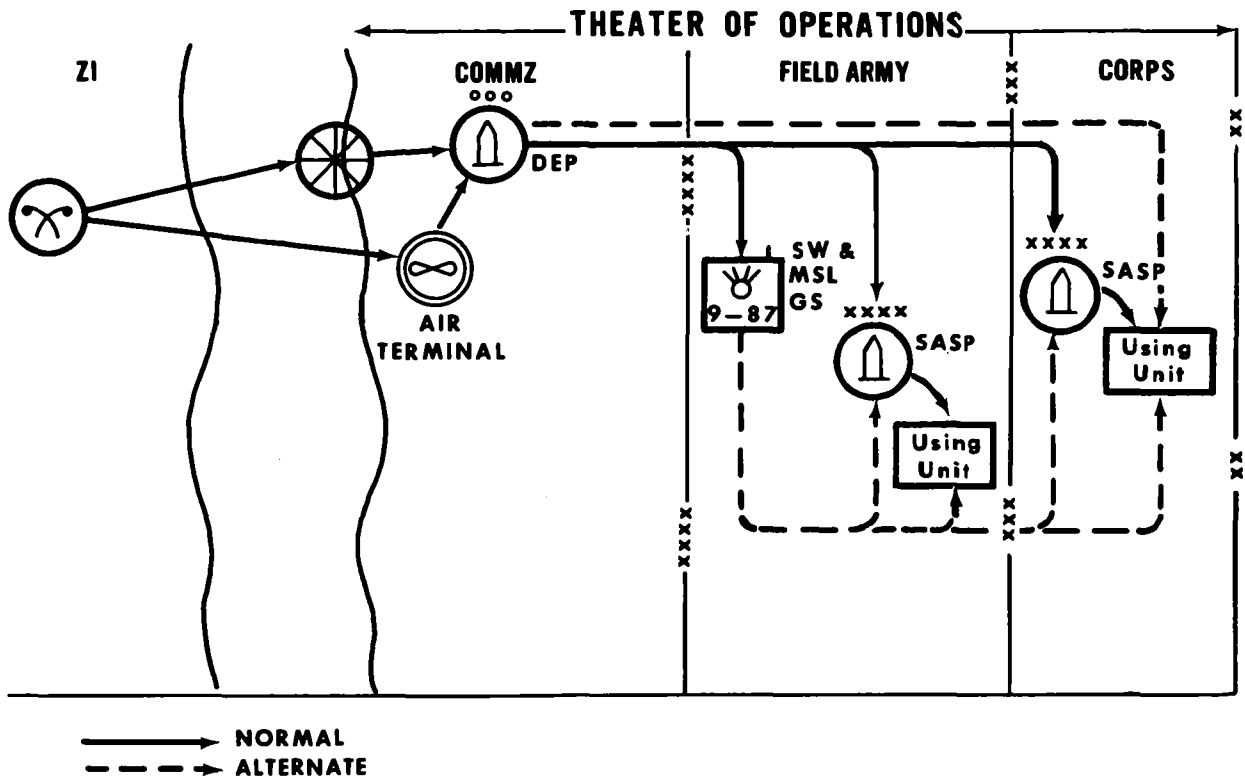


Figure 19. Flow of chemical-filled special ammunition from the ZI through the theater of operations.

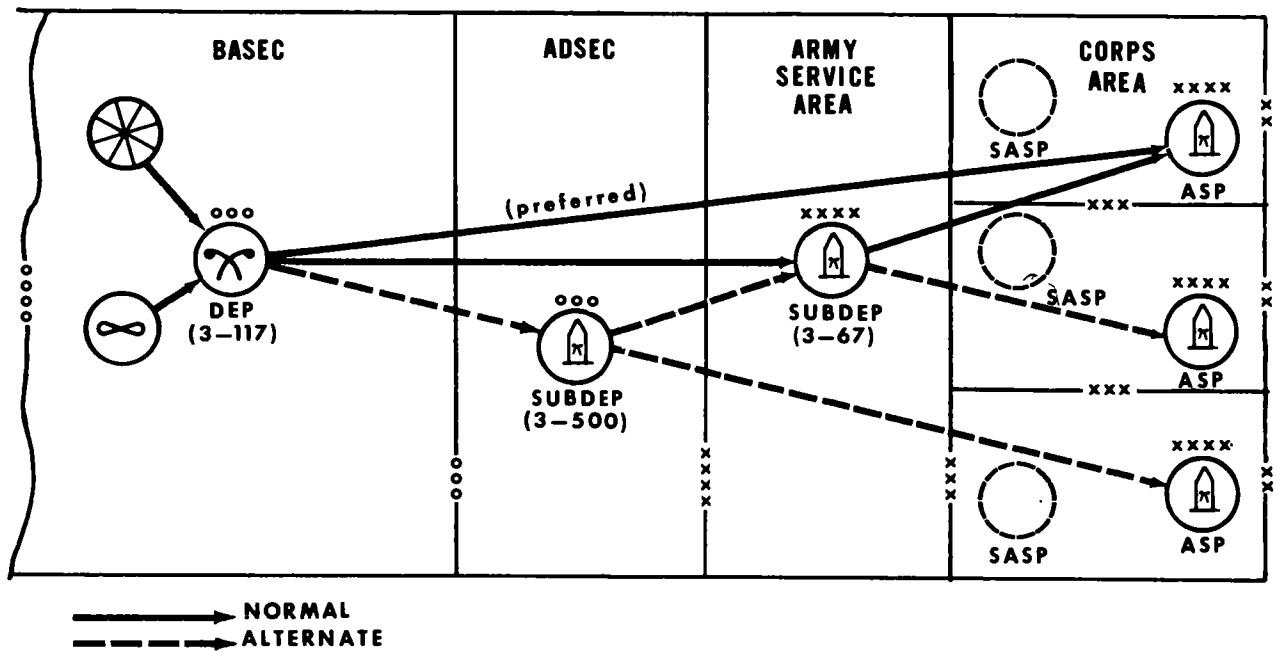


Figure 20. Chemical class V support in a theater: flow of conventional ammunition.

CHAPTER 9

FACTORS AFFECTING THE EMPLOYMENT OF BIOLOGICAL AGENTS

Section I. INTRODUCTION

69. General

The effects of meteorological conditions on a biological agent cloud are generally the same as those on chemical agent clouds, which are discussed in chapter 3. The weather format discussed in paragraphs 3 through 68 also applies to the employment of biological agents. It must be borne in mind, however, that the small infectious doses of biological agents as compared to chemical casualty-producing doses allow a very thin concentration of biological agent to be effective, thus making the downwind travel of a biological cloud more effective than that of a comparative amount of chemical agent. The effects of meteorological conditions on the agents themselves also are dissimilar and are discussed below.

70. Biological Weapons in Military Operations

Biological weapons complement other weapons. They can be used to engage larger target areas than any other weapon and can produce more varied effects. Their characteristics that must be considered in military operations are given below:

a. Large Area Coverage. Biological agents can be disseminated over extremely large areas in casualty-producing concentrations. Thousands of square kilometers may be effectively covered from a single aircraft or missile. The search capability of biological agent clouds and the relatively small dose required to cause infection allow the dissemination of agent to cover large areas where targets are not precisely located but where minimal intelligence indicates enemy formation may be present.

b. Lack of Warning. Attack will usually occur without warning since biological agents may be disseminated by relatively unobtrusive devices functioning at a considerable distance from the target area and relying upon air movement to carry the agent to the target. Only experience and wide dissemination of intelligence will enable the tentative identification of a munition as being

a biological weapon. Biological agents cannot be detected by the unaided senses. Detection and positive identification will usually require appreciable time and laboratory techniques.

c. Delayed Effect. Biological agents do not produce effects immediately. An incubation period is required from the time the agent enters the body until it produces disease. Some agents produce the desired casualty levels from one to three days after infection, whereas other agents may require from one to nine weeks to produce useful casualty levels. Accordingly, plans must be made for sufficient advance delivery for the results to take effect at the desired time.

d. Gradation of Effect. The number and type of agents available provides the commander with the means to select a variety of effects. These effects may vary from a mild illness to one with a high percentage of lethalties. This selectivity provides the commander with the means to apply the required degree of force to accomplish his mission.

e. Penetration of Structures. Agent clouds penetrate fortifications, dwellings, and other structures. This capability of biological agents provides a means for attacking personnel in a fortification that presents a hard target to high-explosive weapons or low-yield nuclear weapons.

f. Nondestruction of Material and Structures. Biological munitions accomplish their effects on targets with little or no physical destruction, depending on the weapons system used. This constitutes an advantage both in combat operations, where it may be essential to save facilities for future use by friendly forces, and in the longer range view to decrease overall requirements for postwar rehabilitation.

g. Degradation of Biological Agent Effect. In most instances, biological weapons produce infection through the respiratory route. Well-fitted military masks in good condition will normally

provide adequate protection against airborne biological agents. Other factors that degrade the effectiveness of a biological attack include the use of protective shelters, the health status of personnel exposed, and the use of preventive medicine.

h. Group Immunity. Population groups within limited geographical areas acquire, through natural processes or by preventive inoculation, a relative immunity to certain diseases. If information on immunity is available, it should be considered and evaluated by the target analyst in his choice of agent and prediction of casualties. Normally, the use of antipersonnel biological agents

involves massive overdoses that tend to degrade natural immunity.

i. Decay of Agent. Biological agents are living organisms that tend to die at predictable rates both while they are stored and after they are released in aerosol form. The storage decay can be minimized by use of controlled refrigeration. Decay in the aerosol cloud varies according to the organism used. It is not a controllable factor at this time, but can be minimized to some degree by releasing the cloud under favorable environmental conditions. Temperature, sunlight, and relative humidity each affect the success of a biological attack (par. 73).

Section II. METEOROLOGICAL AND TERRAIN CONDITIONS

71. Meteorological Conditions

a. Temperature. Within limits, the life processes of all living things slow down at low temperatures and speed up at higher temperatures. Low temperatures (subfreezing to 10° C., or 50° F.) are desirable for employment of biological agents because they reduce the food and oxygen required by the organisms in the aerosol and reduce the evaporation of the liquid droplets carrying the agent.

b. Relative Humidity. High relative humidities are best for dissemination of biological agents in the wet form. Dry agents may be employed efficiently over a wide range of humidities, but they function most efficiently in humidities below 85 percent.

c. Sunlight. The ultraviolet radiation of the sun rapidly kills biological agents. To avoid this

effect, biological agent employment should be planned for the hours of darkness or heavily overcast days.

72. Terrain Conditions

A biological agent cloud is affected in general by topography in much the same way as a chemical agent cloud. The nature of the soil significantly affects the persistency of chemical agents that offer a skin contact hazard. Since biological agents rely almost entirely on inhalation for effect, soil characteristics have little significance. Vegetation tends to remove the aerosol particles from the atmosphere by impaction. Terrain and vegetation conditions, combined with weather conditions, will greatly affect the employment of an agent-vector combination, since the vector will usually seek a favorable environment.

Section III. METHODS OF DISSEMINATION

73. General

The basic methods of disseminating biological agents are the generation of aerosols, the use of insects or animals as vectors, and direct contamination of food and water supplies by means of covert operations. The method used will have an effect on area coverage and the number of enemy personnel infected. It will also be related to the influence that the user will have over the path followed by the agent, as well as to the ease with which the agent can be delivered.

74. Generation of Aerosols

The most effective method of disseminating biological agents is by means of aerosol clouds.

Aerosols may be generated by explosive biological munitions, mechanical generators, and spray devices.

a. Explosives. Explosives utilize a burster charge surrounded by a quantity of the agent. With proper agent-burster ratio, an aerosol is produced upon explosion of the burster. The advantages of this method are its simplicity, high reliability, and low cost. However, the heat and shock of the explosion kill a high percentage of the agent, and the low order of the explosion may identify the munition as one containing biological agent.

b. Mechanical Generators. A mechanical aerosol generator consists of the agent mix, a source of

pressure, a generating device, and a fuze. The advantages of this method of dissemination are that it is relatively quiet, is efficient in producing an aerosol of proper droplet size, and kills less of the agent than the explosion method. The disadvantages of the method are the high cost and the mechanical complexity.

c. Spray Devices. Wet or dry biological agents can be released from spray devices that create an aerosol cloud. The spray devices can be carried by manned aircraft or drones. This method is efficient and economical and offers the possibility of area coverages in terms of thousands of square kilometers.

CHAPTER 10

CONCEPTS OF EMPLOYMENT

75. General

The outstanding military characteristic of biological weapons systems is the capability of providing low cost attrition of enemy manpower over large areas. This manpower may be classified as: military personnel, enemy civilians who contribute to the enemy military effort, and neutral or friendly personnel who are forced to support the enemy. The strategic and tactical use of biological agents must be coordinated so that the use in one area does not reduce effectiveness in the other. These agents should be employed in massive quantities, and forces should be available for the timely exploitation of both the strategic and the tactical advantages that ensue.

a. Tactical Use.

- (1) In offensive action, biological weapons are used against personnel in:
 - (a) Reserve units and support units.
 - (b) Logistical complexes.
 - (c) Lines of communications.
 - (d) Transportation centers.
 - (e) Training areas.
 - (f) Bypassed or isolated targets.
 - (g) Guerrilla forces.
 - (h) Airheads and beachheads.
- (2) In defensive operations, biological weapons are used against all suitable targets forward of the FEBA so as to reduce enemy strength and power to attack.

b. Strategic Use. Strategic targets include personnel in:

- (1) Urban areas.
- (2) Manufacturing complexes.
- (3) Troop rest, training, or staging areas.
- (4) Anti-aircraft defenses.
- (5) Key ports.

- (6) Rail centers, marshalling yards, and railheads.
- (7) Research and development centers.
- (8) Oil fields.
- (9) Missile launching sites.

76. Methods of Employment

The two general methods for delivery of biological agents are:

a. On-Target Attack. In an on-target attack the agent is released over or on the target area. When bomblets or other self-dispersing munitions are delivered directly to the target area, wind direction and velocity are not critical factors, and maximum operational control is provided. Downwind hazards can be reduced by the selection of agents having a high decay rate.

b. Off-Target Attack. In an off-target attack the agent is released upwind of the target area. Once released, the agent is transported to the target area by the wind. The off-target attack prevents enemy awareness of biological agents because of the absence of evidence of a biological attack. Wind direction and velocity, as well as temperature gradient, are critical factors in this type of attack, and operational control is more difficult than with the on-target attack. Target analysis in this case will require particular attention to meteorological and terrain factors.

77. Employment of More Than One Agent on a Target

Logistics and contingent factors permitting, more than one agent may be employed simultaneously in the attack of a target. The advantages of such an attack are obvious. In addition to the greater casualty return obtained, the identification of the agent used will be complicated as will be the enemy medical measures.

CHAPTER 11

BIOLOGICAL TARGET ANALYSIS AND EFFECTS ASSESSMENT

Section I. TARGET ANALYSIS PROCEDURE

78. Introduction

a. Biological target analysis is a process of examining existing and potential targets to determine their vulnerability and suitability for biological attack and the capability of available biological weapons for such attack.

b. The following steps are generally associated with biological target analysis:

- (1) Obtain essential target information.
- (2) In consonance with the commander's concept of operation, identify the targets suitable for biological attack.
- (3) Select suitable agents for producing the desired effects.
- (4) Determine the delivery means available and capable of disseminating the selected agents.
- (5) Determine the biological munition requirements.
- (6) Determine troop safety requirements.
- (7) Prepare recommendations for the employment of biological weapons.
- (8) Make poststrike analysis.

79. Essential Target Information

To allow the efficient employment of biological weapons, as well as the selection of appropriate targets, staff planners must obtain current information on all enemy areas, installations, and personnel within the zone of operations. Information on targets may be obtained from the following sources:

- a. Intelligence reports, including technical intelligence reports.
- b. Situation reports.
- c. Special studies.

80. Identification of Suitable Targets

The target characteristics that influence the employment of biological agents are composition, location, size and shape, permanence, level of enemy personnel protection, and density. The

weather and the terrain, discussed in chapter 9, will have an effect on agent cloud behavior and must also be considered in detail.

a. *Composition.* The target of a biological attack is military personnel, civilian personnel, or a combination of the two. The composition of the target will influence the agent selection. Nonlethal effects may be desired against some targets, whereas a lethal effect may be appropriate against others. Against civilian populations, a delayed onset of incapacitating effects may be acceptable, whereas a military unit presenting an immediate threat may require a more rapid onset of lethal or incapacitating effects.

b. *Location.* The location of the target will influence the choice of weapons systems from the standpoint of range capabilities, accuracy of delivery systems, and the hazard to friendly troops or civil populations. If friendly troops are near the target area, the protective measures available to them (including medical support) may dictate the selection of a delivery system sufficiently accurate to insure that the desired troop safety standard will not be violated. The location of the target with respect to friendly positions and wind direction will determine the point or line of agent release. The tactical or strategic location will have a bearing on selection of an agent with regard to the incubation period. The depth of the target will require a consideration of agent decay rate.

c. *Size and Shape of the Target Area.* The size and shape of the target will influence the choice of the weapons system. The size will dictate the amount of agent necessary for adequate coverage. The configuration will influence the number and location of individual munition coverage patterns.

d. *Permanence.* Targets having little permanence, such as troops massing for assault on a beachhead, will require employment of weapons systems that can be readily employed. Per-

manent targets, such as airfields or supply and maintenance installations, are conducive to more deliberate planning and execution. Although small units may move frequently, they are often restricted to the mission area of a larger unit. In larger units, frequency of movement is reduced; army-size units may be considered relatively static targets. Subordinate units moving within large target areas are more vulnerable to area biological attack than to nuclear and conventional weapons attack. The large area coverage capability of biological weapons enables the commander to engage ill-defined targets of division size or larger.

e. Level of Protection. Susceptibility of target personnel to biological agents may influence the selection of the biological agent to be employed. Level of protection varies with the medical history of the target personnel and the protection available. Personnel without benefit of medical support are more vulnerable than those with such support. Personnel not equipped with detection devices and protective masks are much more vulnerable than those who have masks. Personnel who have survived a previous attack with a particular agent are less susceptible to the same agent on subsequent exposure.

f. Density of Population. The density of population in large target areas will vary from section to section within the area. For this reason, the density of population may influence the selection of biological weapons systems. It may be more profitable and appropriate to launch separate, but simultaneous, attacks against individual subsections of the target.

81. Selection of a Suitable Agent

The selection of agents for biological attack will be based on strategic and tactical requirements. It will depend primarily upon the type of casualty, time of onset, and duration of effects desired by the commander. These factors for standard agents are presented in FM 3-10A. The effects desired by the commander may require modification because of enemy defensive measures and the hazard to friendly forces.

82. Determination of Available Delivery Means

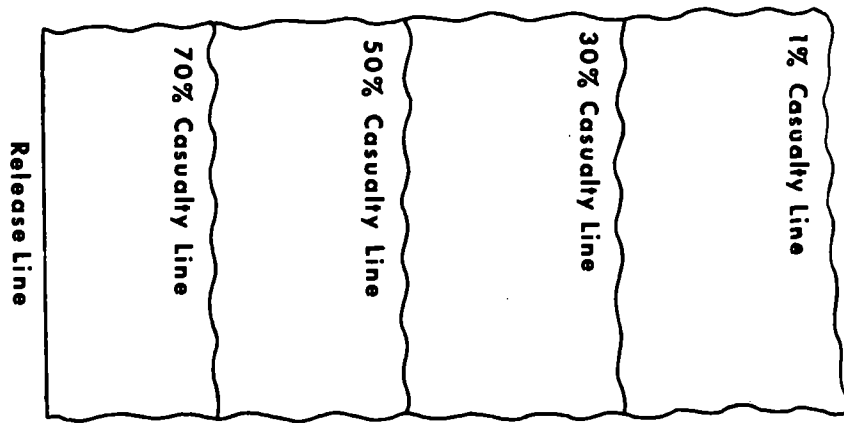
The selection of a delivery means will be based upon the type of release desired, as well as upon the range and accuracy of the system used.

a. The three methods of release are discussed below.

- (1) *Point source release.* A point source disseminates the agent from a single point, as in the case of a stationary generator. Since there are no current plans for the general use of such a generator by the U.S. Army, no method is presented for target analysis employing such a weapon.
- (2) *Line source release.* A line source will disseminate the agent in either a single line or multiple lines, as in the case of continuous release of spray or bomblets from one or more aircraft. In the case of bomblets, the line is actually a series of small point sources that form a strip at ground level (fig. 21). In the case of spray, the result is an elevated release line (fig. 22) and requires special treatment in agent coverage calculations.
- (3) *Multiple point source release.* A multiple point source release is established by the random distribution of self-dispersing bomblets over an area. The bomblets, each acting as a small point source, will disseminate agent throughout the bomblet impact area.

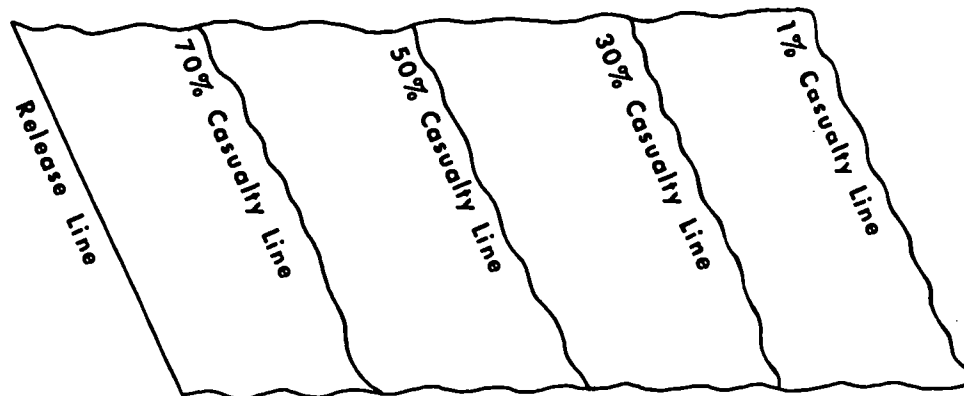
b. The determination of available delivery means capable of disseminating the selected agent on the target consists of the following steps:

- (1) Single out the systems that can disseminate the selected agent.
- (2) Consider only those systems that are within the range of the target.
- (3) Consider only those systems whose casualty level contour patterns and release methods are appropriate for the target size and shape.
- (4) Consider only those systems with the desired accuracy.
- (5) From the target size, target shape, enemy protection level, and weather and terrain conditions, determine the munition requirements for the desired casualty effect and area coverage.
- (6) For each of the systems still under consideration, determine its capability to accomplish the mission or a part of the mission.
- (7) Consider limiting logistical and operational factors.



**Release Line At or Near Ground Level—
Perpendicular to Wind Direction**

»»» Wind Direction —————>



**Release Line At or Near Ground Level—
Not Perpendicular to Wind Direction**

Figure 21. Ground level line source casualty level (dosage level) contour lines.

- (8) Compare (5) and (6) above and tentatively select a system or systems for employment.

83. Determination of Biological Munition Requirements

a. Graphic Method. Using the minimum munition source strength values, munition requirements

for a particular target may be estimated graphically by the following method:

- (1) Construct (to scale) a template representing the shape of the area enclosed by the specified casualty level contour line of a single munition to be used.
- (2) Apply the template to the map outline of the target area.

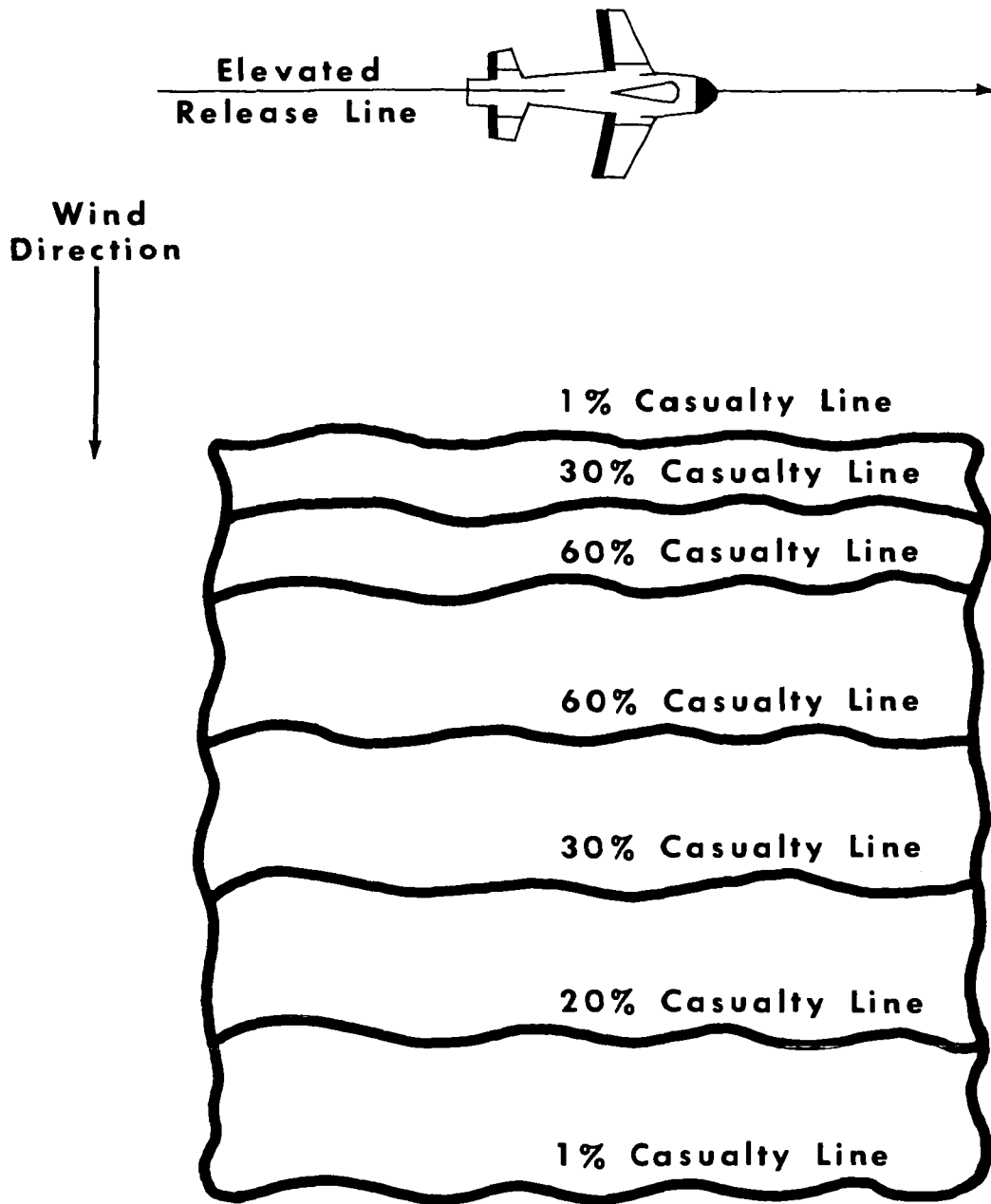


Figure 22. Elevated line source casualty level contour lines.

- (3) The number of template positions required to cover the target area on the map represents the number of munitions required.

b. Source Strength Adjustment Method. Charts and graphs (figs. 24-38 and those in FM 3-10A) may also be used to determine the source strength required for a particular effect. Munition source strengths are additive; therefore, it is possible to

increase source strength by increasing the number of munitions at point, line, or multiple point source. Thus, if a particular aircraft using one spray tank with a North American spray nozzle, disseminating UL at 500 kilometers per hour, has a minimum source strength of 3.1×10^9 median doses per meter, the addition of another tank would increase the source strength to 6.2×10^9 . Two such aircraft with two tanks each could give

a. line source strength of 1.24×10^{10} median doses per meter. The same would hold true for the addition of point sources and multiple point sources. As in *a* above, minimum source strength values are used for calculating effects on the enemy.

84. Determination of Hazard to Friendly Troops

The release of biological agents may cause a hazard to friendly troops due to downwind effects and delivery system error. The downwind hazard is determined by construction of a casualty level contour for the acceptable casualty level. Maximum source strengths are used for these calculations. The delivery error hazard is determined by the establishment of a minimum safe distance from the source. The procedures for determining these hazards are given in chapter 12.

85. Recommendation for the Employment of Biological Weapons

Based on the biological target analysis, recommendations for the employment of biological weapons are submitted to the commander or his representative. As a minimum the recommendations will include:

- a. Location and type of targets to be attacked.
- b. The agent to be used and the predicted casualty effect.
- c. The type and number of munitions required.
- d. Time of attack.

Section II. TARGET ANALYSIS COMPUTATIONS

88. General

a. The biological target analysis computations used in this handbook interrelate three variables: source strength, casualty (or dosage) level, and effective downwind distance. If two of the variables are given, the third can be determined, provided meteorological conditions and agent decay rate are known.

b. This section discusses certain aspects of the parameters and factors used in the target analysis computations.

c. Detailed procedures and computations are illustrated and described in their proper sequence in the sample problems in paragraphs 96 through 100 and in FM 3-10A.

89. Source Strength

a. Source strength is the number of median doses of an organism effective at the point of

e. Limitations on time for completion of delivery.

f. Troop safety considerations and coordination required with adjacent units.

g. Request for the collection of data for post-strike analysis.

86. Poststrike Analysis

The following information should be obtained to determine biological attack effectiveness and to accumulate experience data:

- a. Number and type of casualties.
- b. Number and condition of personnel in the target area at the time of attack.
- c. Agent effectiveness against different types of protection and types of positions.
- d. Enemy countermeasures and their effectiveness.
- e. Effect on enemy morale and efficiency.
- f. Effect on enemy tactics, logistics, and communications.
- g. Effect on friendly forces.
- h. Area coverage and delivery system accuracy.
- i. Actual amount of agent expended.
- j. Meteorological conditions at time of attack.

87. Target Analysis Format

The format for the analysis and detailed comparison of courses of action for the employment of biological agents against enemy targets is essentially the same as that for chemical target analysis, as shown in appendix IV.

dissemination. For a line source, the source strength is expressed as the number of organisms per meter of release line (*q*) divided by the median infectious dose (*d₀*). In the case of multiple point sources, the strength is expressed in median doses per bomblet.

b. For offensive purposes, the source strength used will be the minimum source strength, or that given for the expiration date of the munitions. For troop safety calculations, the maximum source strength will be used. Munitions source strengths for use in calculations are given in FM 3-10A. In the case of aircraft spray, where the aircraft speed and rate of agent flow affect the source strength and the length of the release line, minimum source strength per meter and length of release line may be determined by use of nomograms in FM 3-10A. In this case, the

maximum source strength is found by multiplying the minimum source strength by 16.

c. When a line source is not perpendicular to the wind direction, an adjustment of the source strength is required. The adjustment is made by multiplying the source strength per meter by the cosecant of the acute angle made by the wind direction and the release line. A table of cosecants is given in figure 24.

90. Agent Decay Factor

a. The agent decay factor is determined by dividing the agent aerosol decay rate (given in FM 3-10A) by the wind speed in kilometers per hour. It serves to relate decay to cloud travel distance.

b. In the case of an elevated source, the average wind speed of the layer between the height of release and the ground level is used. If the only wind measurement available is at the 2-meter height, conversion to an average layer wind speed is made by the use of figure 29.

91. Casualty Level (Dosage Level) Contour Line

a. *General.* The concentration of agent in a biological aerosol cloud decreases as the cloud expands and moves downwind. If all points in the path of the cloud receiving a particular dosage (or all points of a specific concentration) are connected by a line, a dosage (or casualty) level contour is produced. The shape of the contour is dependent upon the type of release, the meteorological conditions, and the terrain characteristics.

b. *Line Source.* In the case of an infinite line release, the dosage contour lines do not close. In the case of finite line releases, such lines do close. Since the line releases of biological weapons will be relatively long, it is assumed that the patterns will approximate those for infinite line releases. In an idealized infinite line source situation, such lines would parallel the release line at distances from the release line, as indicated in figure 21. If the release is effected at, or very close to, ground level, the dosage level for the various contour lines is maximum in the area of the release line, as shown in figure 21, and decreases gradually at succeeding greater distances downwind. If the release is effected at some elevation above ground, the dosage pattern is different, as shown in figure 22. The agent cloud makes contact with the ground downwind from the release line along a series of lines, which may be

referred to as casualty level contour lines. The dosage level for the various casualty level contour lines increases from a minimum at initial contact to a maximum at a relatively short distance downwind and then decreases gradually at succeeding greater distances downwind. The distance downwind to specific low percentage casualty level contour lines depends upon the source strength, the height of release, the meteorological conditions, and the terrain conditions. In the case of line releases near ground level, this distance will be small compared to the great distances travelled downwind by an agent cloud, and consequently it is ignored. For elevated releases, this distance is significant and requires consideration.

c. *Multiple Point Source.* Casualty level contour lines are not constructed for multiple point sources, as the bomblets are considered to be effective only in the impact pattern with casualty levels being based on the bomblet dispersion. The casualty effect is varied by adjusting the diameter of the pattern by means of different heights of release.

92. Spaced Multiple Release Lines

When multiple line sources are not in the same general line, the dosage (or casualty) level is found by means of the following procedures:

a. Find the dosage for the downwind boundary of specified casualty levels for each line of release.

b. Add the dosage levels from each line source that overlaps each area or line of interest.

c. Find the casualty level for the sum of dosages thus found.

93. Correction Factors

Correction factors for agent cloud downwind distance are given in figure 25. The factors are tentative, since the data to support the figures given are limited.

a. *Natural Cover.* The degrading effect of natural cover on diffusion and cloud travel depends upon the weapons system employed.

b. *Precipitation.* The degrading effect of precipitation on diffusion and cloud travel is applicable, regardless of the type of weapons system employed.

c. *Immunization.* The degrading effect of immunization on casualty response depends upon the type and extent of this protection afforded the target personnel. In the absence of definitive estimates in this connection, as might be derived

through intelligence sources, it is recommended that a factor of 0.5 be applied in those instances where mass immunization is known to have been administered.

d. Individual Protection. It is estimated that 75 to 95 percent of all enemy forces will be protected by efficient protective masks and that the remainder will be exposed as a result of faulty, ill-fitting, or lost masks or as a result of faulty protective mask discipline. A factor of 0.05 to 0.25, depending on intelligence information, should be applied to casualty estimations when it has been determined that protective masks have been issued and there is reason to assume that the enemy is warned.

e. Physical Protection. Tests indicate that, after considerable time, dosage readings inside enclosed fortifications, buildings, and vehicles are substantially the same as those on the outside. Consequently, no correction factor is required for this target characteristic. It is only necessary to determine whether to use the open terrain nomogram, the built-up terrain nomogram, or both nomograms together. If target personnel are located in what is predominantly open terrain, the open terrain nomograms should be used. If they are in an area that is predominantly built-up, the built-up terrain nomograms should be used. When large areas of both types exist in the target area, the analyst can divide the target area by type of terrain and treat each different section as a separate target, using the appropriate nomograms.

94. Terrain—Open or Built-up

a. Target analysis nomograms are presented for two types of terrain: open and built-up. The open terrain nomograms are for use by day or night under inversion, neutral, or lapse conditions. The built-up terrain nomograms and graphs give data for night only under the following conditions:

- (1) *Condition A*—clear or scattered night sky; wind speed of 5 to 15 kilometers per hour.
- (2) *Condition B*—any sky condition at night; wind speed over 15 kilometers per hour.
- (3) *Condition C*—broken or overcast sky at night; wind speed of 5 to 15 kilometers per hour.

b. No multiple point source graphic aids are included for condition C or lapse conditions, because a biological attack with a multiple point source weapon would probably be ruled out under such conditions.

95. Estimation of Casualties Over Large Areas (Integrated Casualties)

Two methods are provided for the estimation of casualties over large areas:

a. Average Fraction of Casualties (When Target Information Is Lacking). This method, based on the Simpson's rule, assumes a uniform distribution of personnel within the area. It is employed over an area in which the overall target is not specifically defined as to size, composition, and location of individual targets within the area. This method is useful in determining the capability of a biological weapon during initial planning stages. It is also a rapid means of estimating a casualty level effect from a biological weapon employed over a large area.

- (1) *Line source release at ground level (up to 30 meters).* To obtain the average casualty level over an area to a given downwind distance (X):

- (a) Divide the distance (X) by 6 and get the distances:

$$0, \frac{1}{6}X, \frac{2}{6}X, \frac{3}{6}X, \frac{4}{6}X, \frac{5}{6}X, \text{ and } X.$$

Enter these distances in column (1) of the computation form, figure 23.

- (b) For each distance in column (1), find, using appropriate nomogram and charts, the casualty level, and enter it in column (2).
- (c) Multiply column (2) by column (3) and enter the products in column (4).
- (d) Add column (4). The integrated casualty level is one-eighteenth of the sum.
- (2) *Line source release at elevations above 30 meters.* No reliable method can be devised at this time for estimating average casualty levels in the case of release above 30 meters.

b. Total Number of Casualties (When Specific Target Information Is Known). It is assumed for this method that targets within the target area complex are clearly defined as to size, location, and population. The population is assumed to be centrally located within specific targets and that a population void exists outside the specific targets. The casualty level is determined for each specific target and converted to the number of casualties for each specific target. These are totaled to give the number of casualties in the entire target complex.

	(1)	(2)		(3)		(4)
0 →	0 Km	0%	x	1	=	0
$\frac{1}{6}x$ →	6 Km	99%	x	4	=	396
$\frac{2}{6}x$ →	12 Km	88%	x	2	=	176
$\frac{3}{6}x$ →	18 Km	14%	x	4	=	56
$\frac{4}{6}x$ →	24 Km	2%	x	2	=	4
$\frac{5}{6}x$ →	30 Km	1.5%	x	4	=	6
x →	36 Km	1%	x	1	=	1

Total 639 + 18 = 35.5%

35.5% Integrated casualty level.

Figure 23. Integrated casualties computation format

Section III. SAMPLE PROBLEMS

96. Introduction

a. General. This section and FM 3-10A contain sample problems that serve to illustrate the methods of computing biological munitions effects. It should be noted that in the case of an elevated line source, there is no means provided for finding the downwind distance, even though a desired casualty level, a source strength, and meteorological conditions are known. To solve such a problem, the analyst must use trial-and-error methods, assuming different downwind distances and solving for casualty level until he approaches that desired. It should also be noted that the casualty levels used are for unprotected personnel.

b. Source Strength Data. Source strength for use in biological target analysis may be calculated in detail by a target analyst, using the fill-strength and half-life data given in FM3-10A, information accompanying individual munitions, and the delivery means characteristics. To avoid the need for these detailed calculations, the basic source strength data for operational use (minimum effective source strength) are given in FM3-10A. These source strengths are based on agent con-

centration after four half lives in storage. The *maximum* effective source strength, also given in FM3-10A, is for use in troop safety calculations. Ground level line source strengths must be computed by the analyst, based on the weapons system employed and the method of employment, in order to establish the source strength in doses per meter of release line. In the case of elevated line sources (aircraft spray), the source strength is determined from FM3-10A. Source strength is given in median doses per meter of release line as a function of aircraft speed and flow rate of agent. Nomograms in FM3-10A give the length of the release line as a function of aircraft speed, flow rate, and spray tank capacity. These nomograms may also be used to adjust flow rate and aircraft speed for a desired source strength and length of release line. Adjustment for the use of more than one spray tank or more than one aircraft on the same general line may be made by multiplying the appropriate factor (number of spray tanks) by either the flow rate of one tank or the computed source strength of one spray tank. If the individual source strengths are different,

they will have to be added, since a factor will not be applicable.

c. Following are definitions of special terms and symbols used in the solution of problems:

- (1) Q = total number of organisms released (fill volume $\times$ fill concentration $\times$ dissemination efficiency).
- (2) q = organisms per meter of release line.
- (3) d_0 = infectious (median) dose.
- (4) $\frac{Q}{d_0}$ = total number of infectious doses.
- (5) $\frac{q}{d_0}$ = infectious doses per meter of release line.
- (6) $\bar{U}$ = wind speed.
- (7) D = organisms minutes per cubic meter (concentration of agent in terms of organisms).
- (8) $\frac{D}{d_0}$ = median dose minutes per cubic meter (concentration of agent in terms of infectious doses).
- (9) Agent decay factor = agent decay rate $\div$ wind speed.
- (10) $\frac{D}{q}$ = ratio of agent concentration to original source strength.
- (11) c = diffusion coefficient.

97. Line Source at Ground Level

Problem 1. To determine the maximum downwind distance to a specific casualty level.

a. *Given:*

- (1) Length of release line: 3,000 meters
- (2) Temperature gradient: Inversion
- (3) Wind Speed: 8 kilometers per hour
- (4) Agent decay rate: 5 percent per minute
- (5) Terrain characteristics: Open
- (6) Munitions source strength: 4×10^7 median doses per meter
- (7) Relative Humidity: 90 percent.

b. *Find:* The maximum downwind distance to the 30 percent casualty level contour line.

c. *Procedure:*

- (1) Turn to figure 26.
- (2) Place a hairline between 4×10^7 median doses per meter on scale A and the "inversion" point on scale C. Fix the hairline on the point of intersection with the reference line, scale B.

- (3) Pivot the hairline to the 30 percent casualty level on scale E. Read 10 as the NEN at the point where the hairline crosses scale D.
- (4) Turn to figure 28.
- (5) Place a hairline between 10 on the open terrain NEN scale and 0.63 (5%/8 km per hr) on the decay factor scale. Read about 10 kilometers at the point where the hairline crosses the inversion downwind distance scale.

Problem 2. To determine the casualty level at a given distance downwind.

a. *Given:* All conditions are the same as in Problem 1, above.

b. *Find:* The casualty level at 10 kilometers downwind from the release line.

c. *Procedure:*

- (1) Turn to figure 28.
- (2) Place a hairline between 10 kilometers on the open terrain inversion downwind distance scale and 0.63 on the decay factor scale. Read 10 as the NEN at the point where the hairline crosses the NEN scale.
- (3) Turn to figure 26.
- (4) Place a hairline between 4×10^7 median doses per meter on scale A and the "inversion" point on scale C. Fix the hairline on the point of intersection with the reference line, scale B.
- (5) Pivot the hairline to 10 on the NEN scale, scale D. Read about 30 percent as the casualty level at the point where the hairline crosses scale E.

Problem 3. To determine area coverage to a casualty level contour downwind.

a. *Given:* The conditions are the same as in Problem 1, above.

b. *Find:* Area coverage from the release line to the 30 percent casualty level contour line.

c. *Procedure:*

- (1) Find the maximum downwind distance of 10 kilometers using the procedure demonstrated in Problem 1.
- (2) Multiply the downwind distance of 10 kilometers by the length of the release line of 3,000 meters (3 kilometers) to obtain 30 square kilometers as the area between the release line and the 30 percent casualty level contour line.

98. Elevated Line Source

Problem 1. To determine the casualty level associated with a specific downwind distance for an elevated line release.

a. Given:

- (1) Munition source strength: 10^{10} median doses per meter $\left(\frac{q}{d_0}\right)$.
- (2) Temperature gradient: Inversion
- (3) Wind speed at 2 meter height: 10 kilometers per hour.
- (4) Agent decay rate: 10 percent per minute.
- (5) Terrain characteristics: Open
- (6) Height of release: 100 meters
- (7) Relative humidity: 80 percent.

b. Find: The casualty level 20 kilometers downwind.

c. Procedure:

- (1) Turn to figure 29 to convert the 2 meter wind speed (10 kilometer/hr—inversion) to an average layer wind speed. Read 20 kilometers per hour for a release height of 100 meters.
- (2) Turn to figure 30 to find the diffusion coefficient.
- (3) Place a hairline between the inversion height of release scale, Scale B, at 100 meters and 20 kilometers on the inversion wind speed scale, scale A. Read the value of the diffusion coefficient as 0.066 on scale C.
- (4) Turn to figure 31.
- (5) Place a hairline between the specified downwind distance (20 km) on scale X and the inversion point on the temperature gradient scale to intersect scale R_1 .
- (6) Place a hairline between the intersection on scale R_1 (step 5) and 0.066 on scale C, read 3.8×10^4 on scale F_1 .
- (7) Place a hairline between the height of release (100 meters) on scale R_1 and the value of F_1 (3.8×10^4) on scale F_2 , intersecting scale R_2 .
- (8) Place a hairline between 20 kilometers per hour on scale $\bar{U}$ and the point located on scale R_2 (step 7). Read 1.4×10^{-5} on scale $\frac{D}{q}$. This value is the ratio of the dosage downwind to the dosage at the release line.
- (9) Multiply $1.4 \times 10^{-5} \left(\frac{D}{q}\right)$ by $10^{10} \left(\frac{q}{d_0}\right)$ to obtain 1.4×10^5 median dose minutes

per cubic meter at a downwind distance of 20 kilometers from the release line, no decay rate being considered.

- (10) Turn to figure 32 to find the fraction of agent remaining.
- (11) Place a hairline between 20 kilometers downwind distance on scale C and $\frac{10}{20}$ or 0.5 (agent decay rate/average layer wind speed) agent decay factor on scale A. Read 0.003 as the fraction of agent remaining on scale B.
- (12) Multiply fraction of agent remaining (0.003) by median doses (1.4×10^5) (Step 9) to obtain 4.2×10^2 median dosage at 10 percent per minute agent decay 20 kilometers downwind.
- (13) Turn to figure 26 to find casualty level.
- (14) Opposite 4.2×10^2 median dose minutes/ M^3 on scale E read a casualty level of about 95%.

99. Multiple Point Source

Problem 1. To determine fraction of casualties in an area covered by 500 bomblets filled with 10^8 median doses of a biological agent having a decay rate of 5 percent per minute.

a. Given:

- (1) Number of bomblets: 500
- (2) Area of bomblet impact zone: 100 square kilometers.
- (3) Source strength per bomblet: 10^8 median doses.
- (4) Temperature gradient: Neutral.
- (5) Agent decay rate: 5 percent per minute.
- (6) Terrain characteristics: Open.
- (7) Relative humidity: 80 percent.

b. Find: The fraction of casualties in the impact area.

c. Procedure:

- (1) Find bomblet density in the impact zone from given data: $\frac{500}{100} = 5$ bomblets per square kilometers.
- (2) Turn to figure 34.
- (3) Place a hairline vertically through 10^8 median doses on the horizontal source strength per bomblet scale. Read the density of bomblets, 15, at the point on the vertical bomb density scale opposite the point of intersection of the hairline with the 100 square kilometer curve for 70 percent casualties.

- (4) Divide the given density, 5 (step 1) by 15 (step 3) to obtain 0.33 as the ratio of densities.
- (5) Examine the factor table in the upper right of the graph to find the factor opposite 10^8 that comes closest to 0.33 ratio of densities. A casualty level of greater than 30 percent and less than 50 percent is expected.

Problem 2. To determine the number of bomblets required to produce a specified average percentage of casualties in a specified area:

a. Given:

- (1) Impact area: 225 square kilometers.
- (2) Type of bomblet: Same as problem 1, above.
- (3) Meteorological condition: Condition B.
- (4) Agent decay factor: 5 percent per minute.
- (5) Source strength per bomblet: 10^8 median doses.
- (6) Terrain: Built-up.

b. Find: The number of functioning bomblets required in the given area to produce 50 percent casualties.

c. Procedure:

- (1) Turn to figure 36.
- (2) Place a hairline vertically through 10^8 median doses on the horizontal strength per bomblet scale. Read the density of bomblets, 19, at the point of intersection of the hairline with the 225 square kilometer curve for 70 percent casualties.
- (3) Find the correction factor, 0.57, for 50 percent casualties opposite 10^8 in the table of factors in the upper right-hand corner of figure 36.
- (4) Multiply the density, 19 (step 2), by the correction factor, 0.57 (step 3) to obtain a bomb density of 11.
- (5) Multiply the impact area, 225 square kilometers, by the bomblet density to obtain 2475 bomblets, the number of bomblets required to produce 50 percent casualties.

100. Sample Problem for Application of Correction Factors

a. Given:

- (1) Type of release: line source at ground level.
- (2) Downwind distance of cloud to the 50 percent casualty level contour line: 10 kilometers.
- (3) Type of natural cover: heavily wooded, hilly.
- (4) Precipitation: moderate rainfall.
- (5) Enemy medical protective measures: Target personnel are immunized.
- (6) Individual protection: Target personnel do *not* have masks.

b. Find: The corrected downwind distance under the prevailing conditions.

c. Solution:

- (1) The correction factors from figure 25 for the existing conditions are:

Heavily wooded, hilly terrain....	0.6
Moderate rainfall.....	0.2
Target personnel immunized.....	0.5

- (2) Multiplication of these individual correction factors will give an overall correction factor of 0.06.
- (3) By applying the overall correction factor of 0.06 to the downwind distance (10 km x 0.06), a corrected downwind distance of 0.6 kilometer is obtained for a 50 percent casualty level.

Acute angle formed by wind direction and line of release (degrees)	Source strength adjustment factor (cosecant)
80	1.01
70	1.06
60	1.15
50	1.3
45	1.4
40	1.55
30	2.0
20	2.9
10	5.7

Figure 24. Source strength adjustment factors for line source strength when the angle between line of release and wind direction is other than perpendicular.

Conditions	Line source		Multiple point source
	Ground level ¹	Elevated	(Bomblet system)
<i>Type of terrain</i>			
Heavily wooded, hilly or mountainous.....	0.6	0.5	0.6
Dense jungle or rain forest..	0.2	0.1	0.2
<i>Precipitation</i>			
Moderate rainfall.....	0.2	0.2	0.2
<i>Immunization</i>			
Target personnel immunized..	0.5	0.5	0.5
<i>Individual protection</i>			
Masks worn by target personnel:			
Well trained.....	0.10	0.10	0.10
Poorly trained.....	.25	.25	.25

¹ Includes bomblets released along a line and functioning at ground level

Figure 25. Table of correction factors to be multiplied by downwind distance (figures given are assumed).

A
SOURCE STRENGTH
 $\frac{q}{d_0}$
LOW RANGE 10¹¹ HIGH RANGE 10¹⁷
MEDIAN DOSES PER METER

B
REFERENCE LINE

C
METEOROLOGICAL CONDITIONS
○ ← LAPSE
○ ← INVERSION
NEUTRAL → ○

D
NOMOGRAM ENTRY NUMBER (NEN)
LOW RANGE 50 HIGH RANGE 44
50 44
28 42
26 40
24 38
22 36
20 34
16 32
16 30
14 26
12 26
10 24
8 22
6 20
4 18
2 16
0 14
-2 12

E
CASUALTY LEVEL (PERCENT)
 $\frac{D}{d_0}$
(MEDIAN DOSE MINUTES/M³)

A to C $\longrightarrow$ **B**
B to E $\longrightarrow$ **D**

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ENTRY NUMBER NOMOGRAM

LINE SOURCE - BUILT-UP TERRAIN

GROUND LEVEL RELEASE

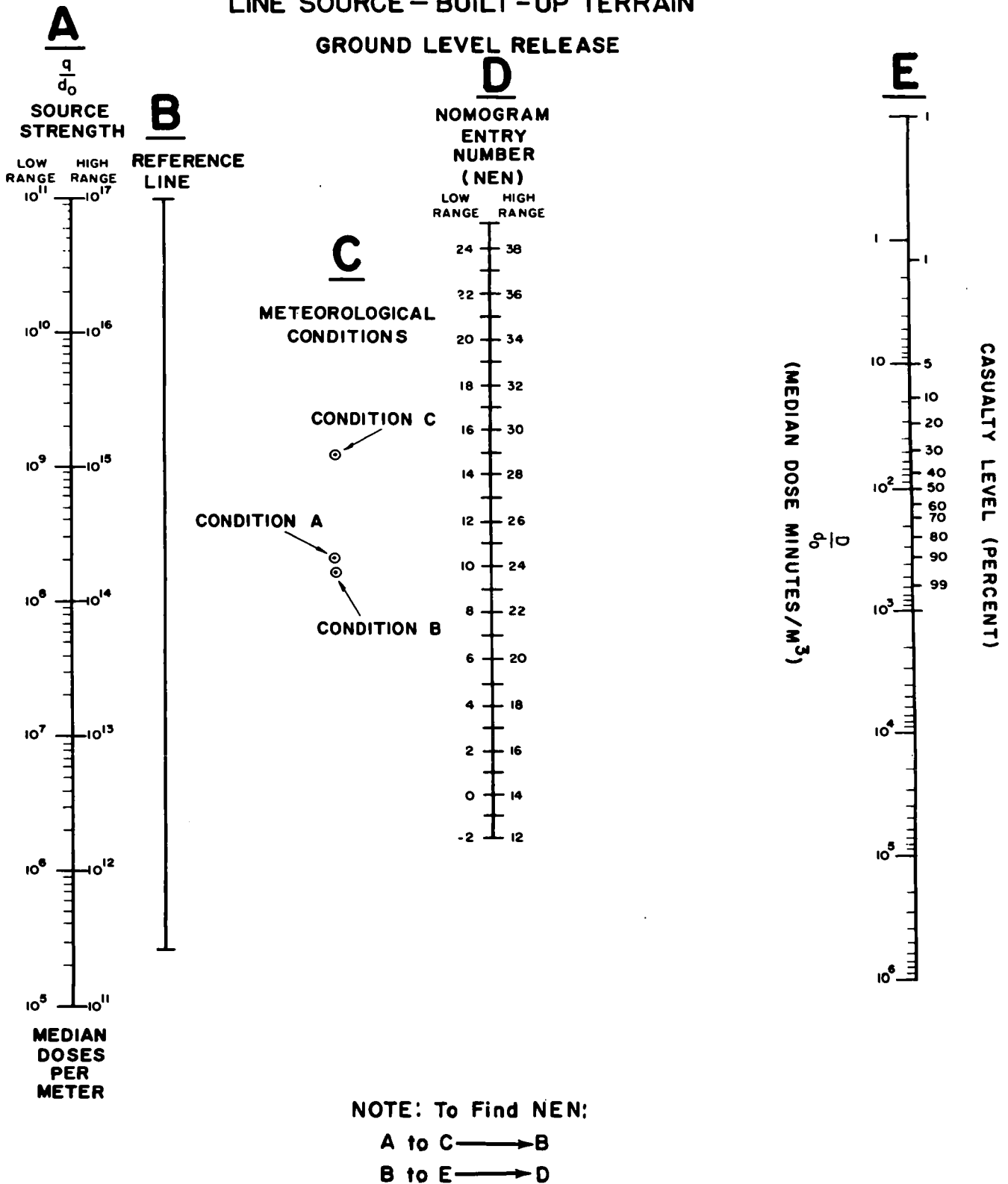
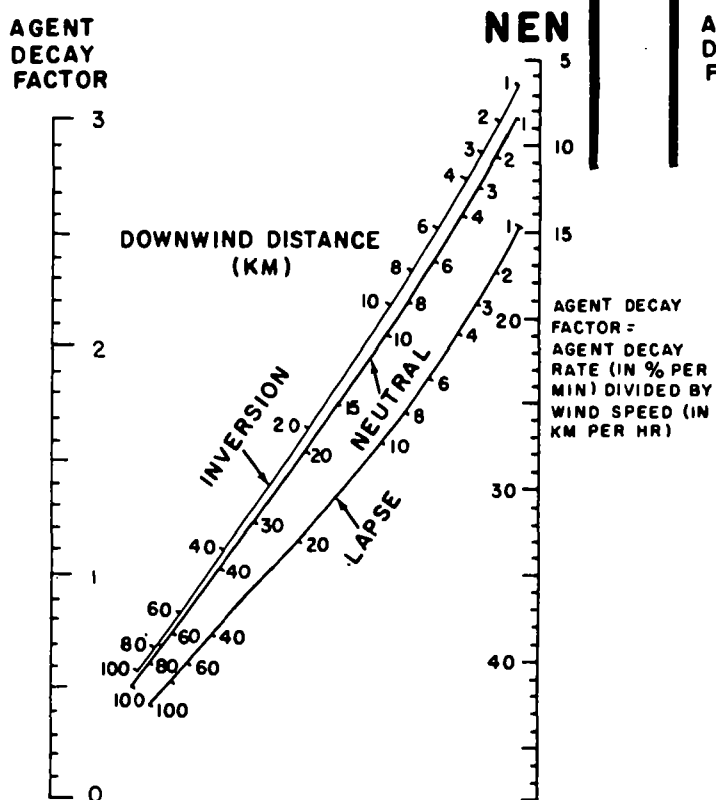


Figure 27. Nomogram for determining the entry number for a line source at ground level in built-up terrain.

DOWNWIND DISTANCE NOMOGRAM LINE SOURCE GROUND LEVEL RELEASE

OPEN TERRAIN



BUILT-UP TERRAIN

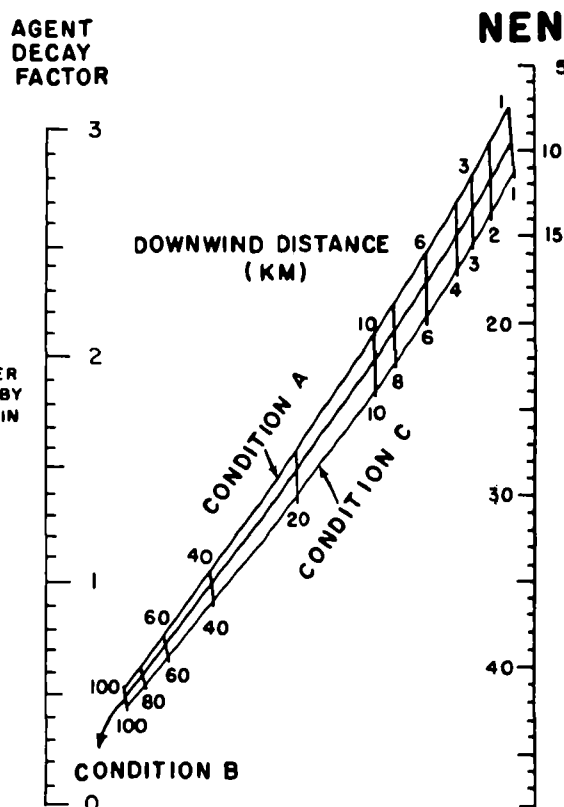


Figure 28. Nomogram for determining downwind distance for a line source at ground level.

Wind speed at 2-meter level (km/hr)	Average layer wind speed in kilometers per hour		
	Release height of 50 meters	Release height of 100 meters	Release height of 150 meters
<i>Inversion</i>			
5.....	8	10	11
10.....	15	20	22
15.....	22	29	32
<i>Neutral or lapse</i>			
8.....	10	11	13
16.....	20	22	24
24.....	30	33	37
32.....	40	45	50

Figure 29. Table for conversion of 2-meter wind speeds to average layer wind speeds for use in elevated line source calculations.

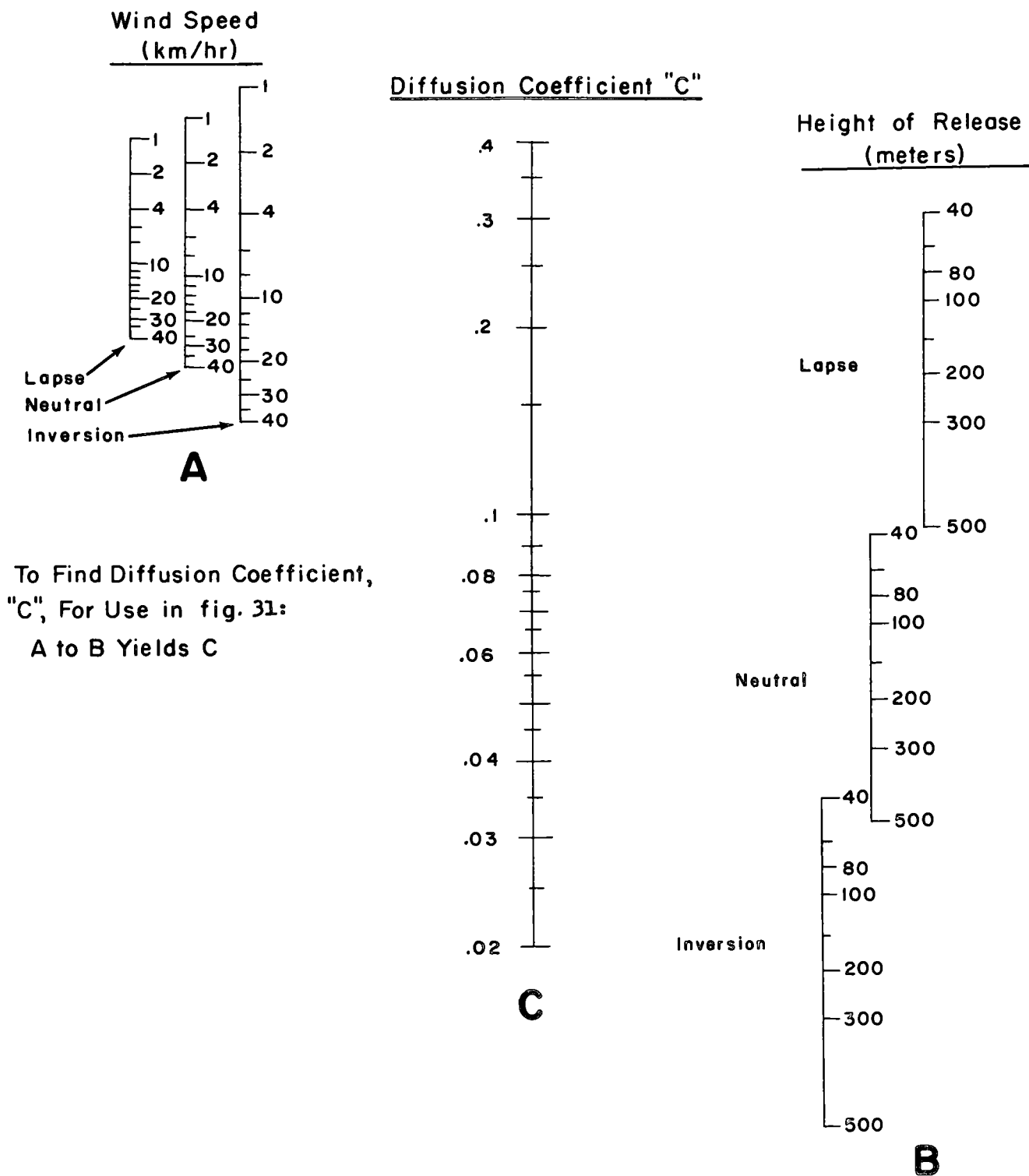


Figure 30. Nomogram for determining the diffusion coefficient for use in an elevated line source.

$\frac{D}{q}$ — DOWNWIND DISTANCE NOMOGRAM
LINE SOURCE OPEN OR BUILT-UP TERRAIN
ELEVATED RELEASE

NOTE: To find $\frac{D}{q}$ Using C

Found in fig. 30:

X to TG $\rightarrow R_1$

R_1 to C $\rightarrow F_1$

Using F_1 on F_2 scale,

H to $F_2 \rightarrow R_2$

R_2 to $\bar{U} \rightarrow \frac{D}{q}$

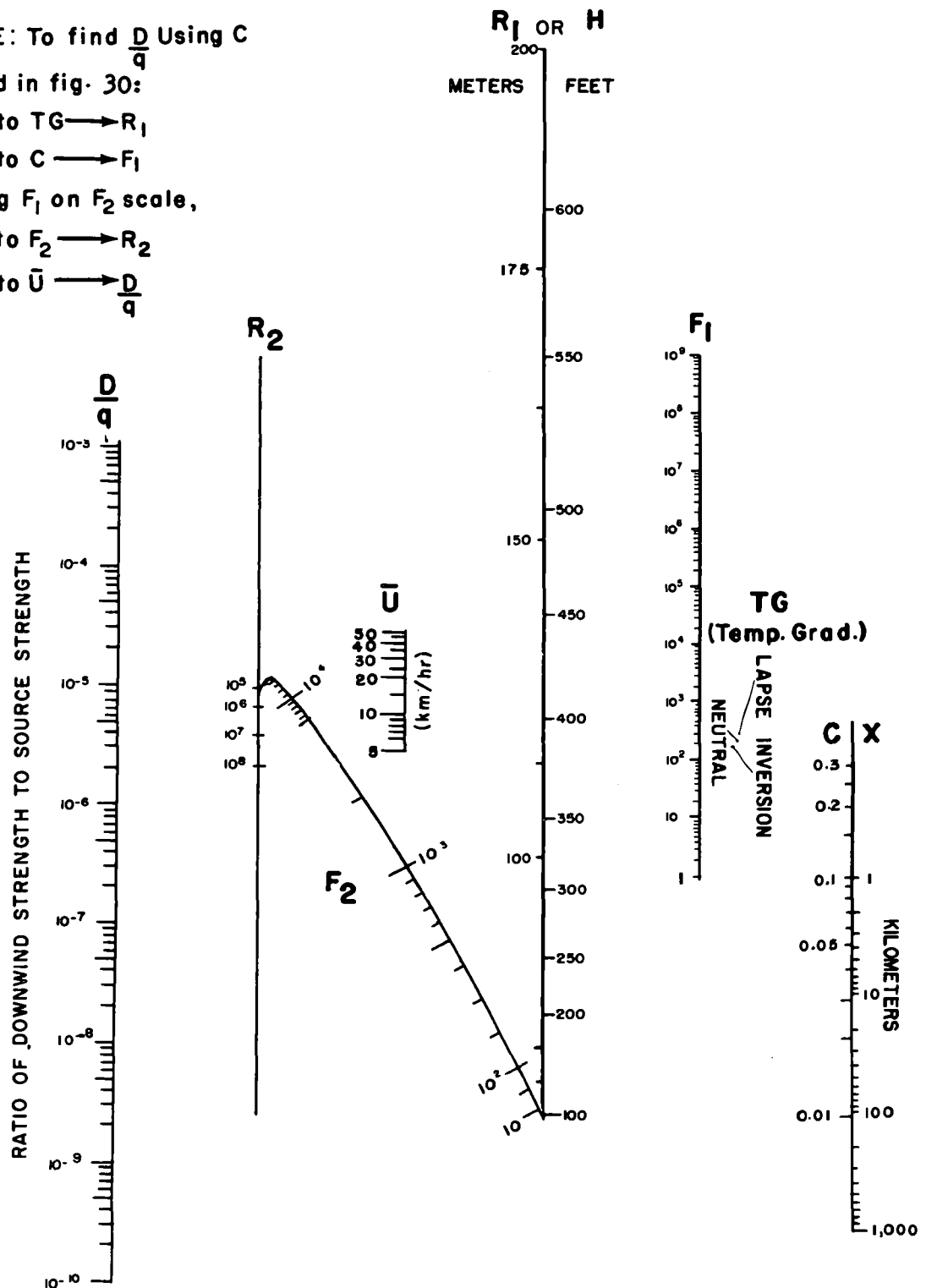


Figure 31. Nomogram for determining $\frac{D}{q}$ at a given downwind distance for a line source above ground level. (Decay factor not considered.)

DECAY RATE NOMOGRAM (ELEVATED LINE SOURCE)

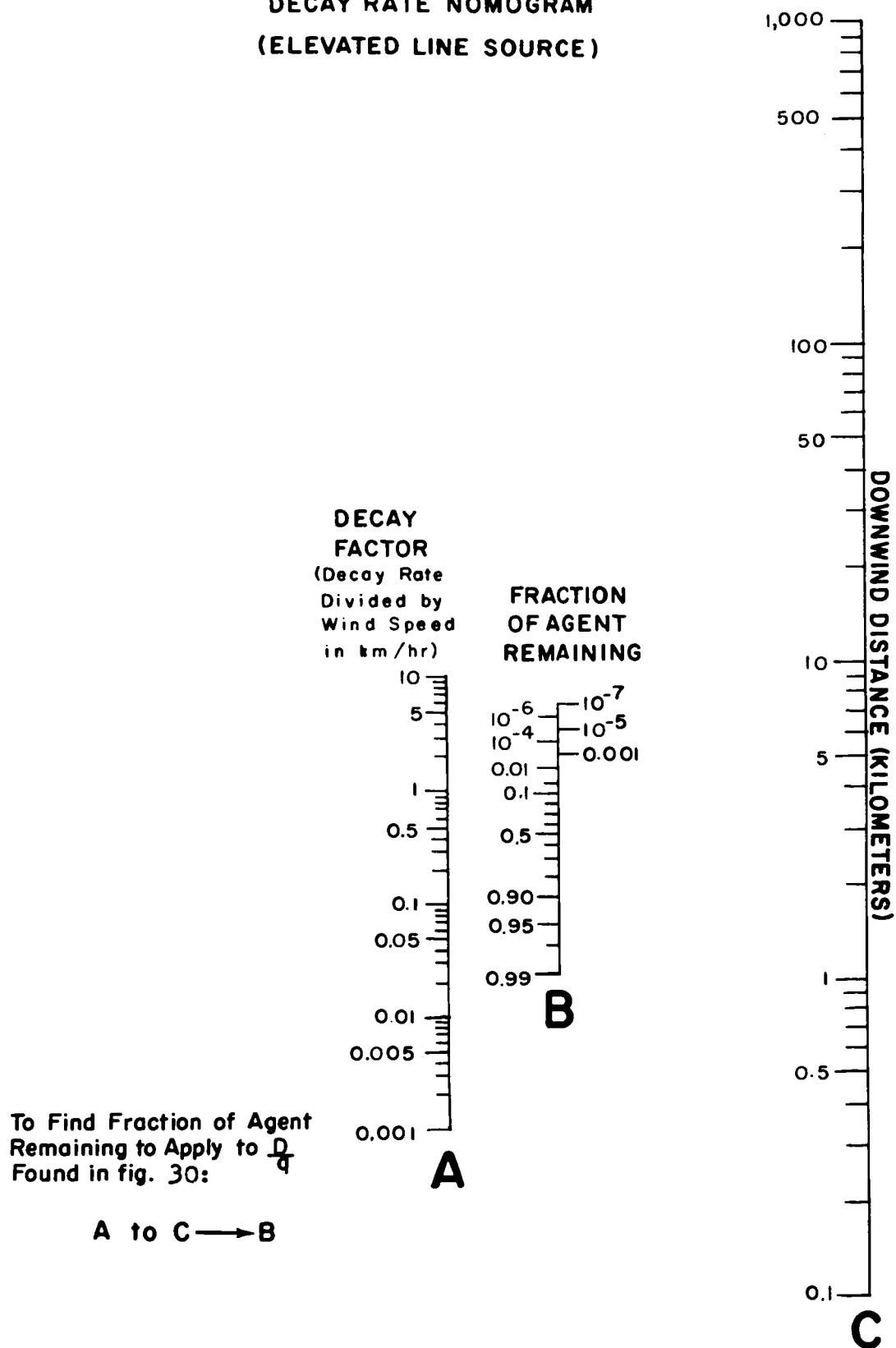


Figure 32. Nomogram for determining agent decay for a line source above ground level.

MULTIPLE POINT SOURCE IN AN AREA
OPEN TERRAIN—INVERSION
DECAY RATE—0% - 5%
CASUALTY RESPONSE—70%

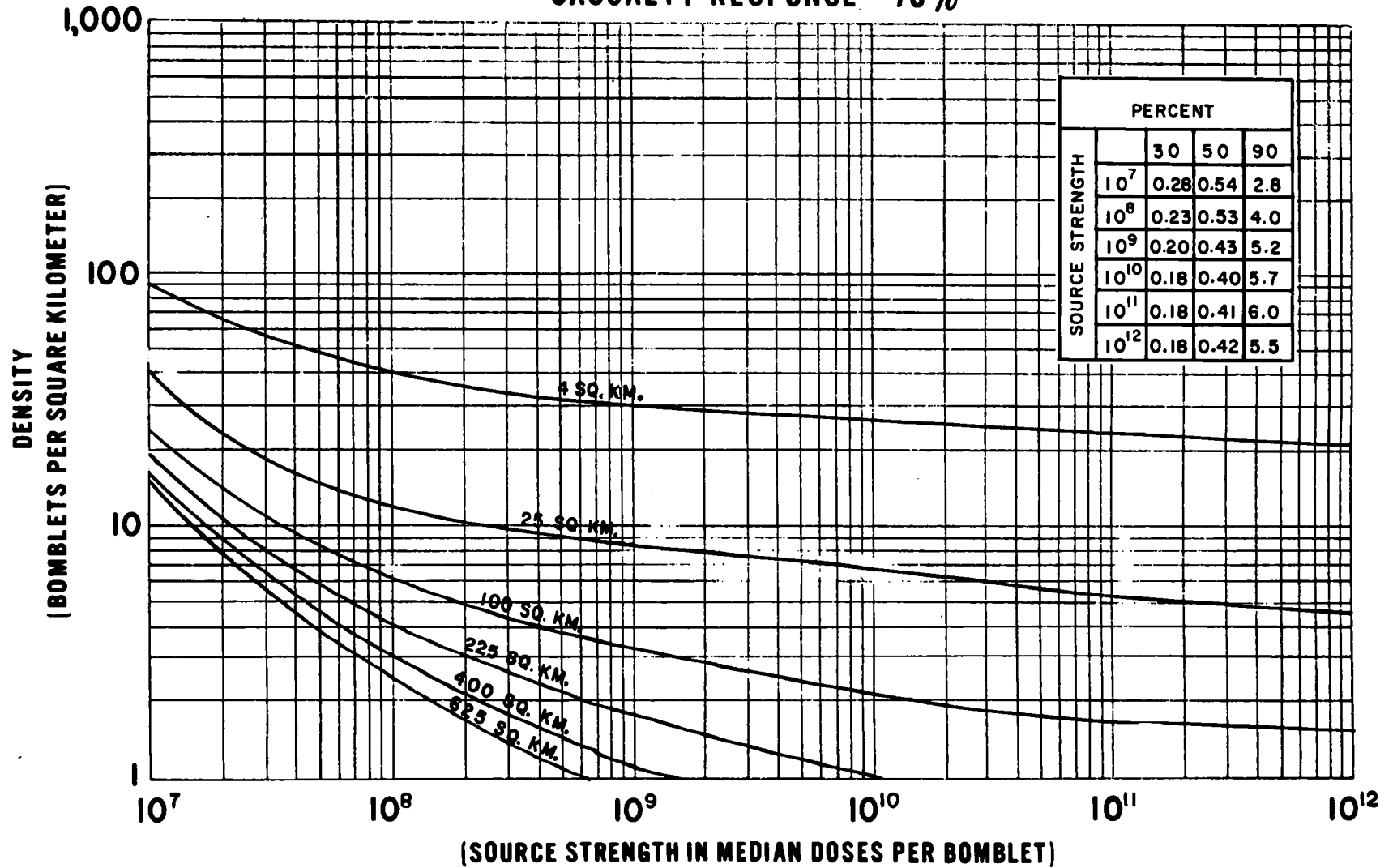


Figure 33. Graph for multiple point source target analysis.

MULTIPLE POINT SOURCE IN AN AREA
 OPEN TERRAIN—NEUTRAL
 DECAY RATE—0%-5%
 CASUALTY RESPONSE—70%

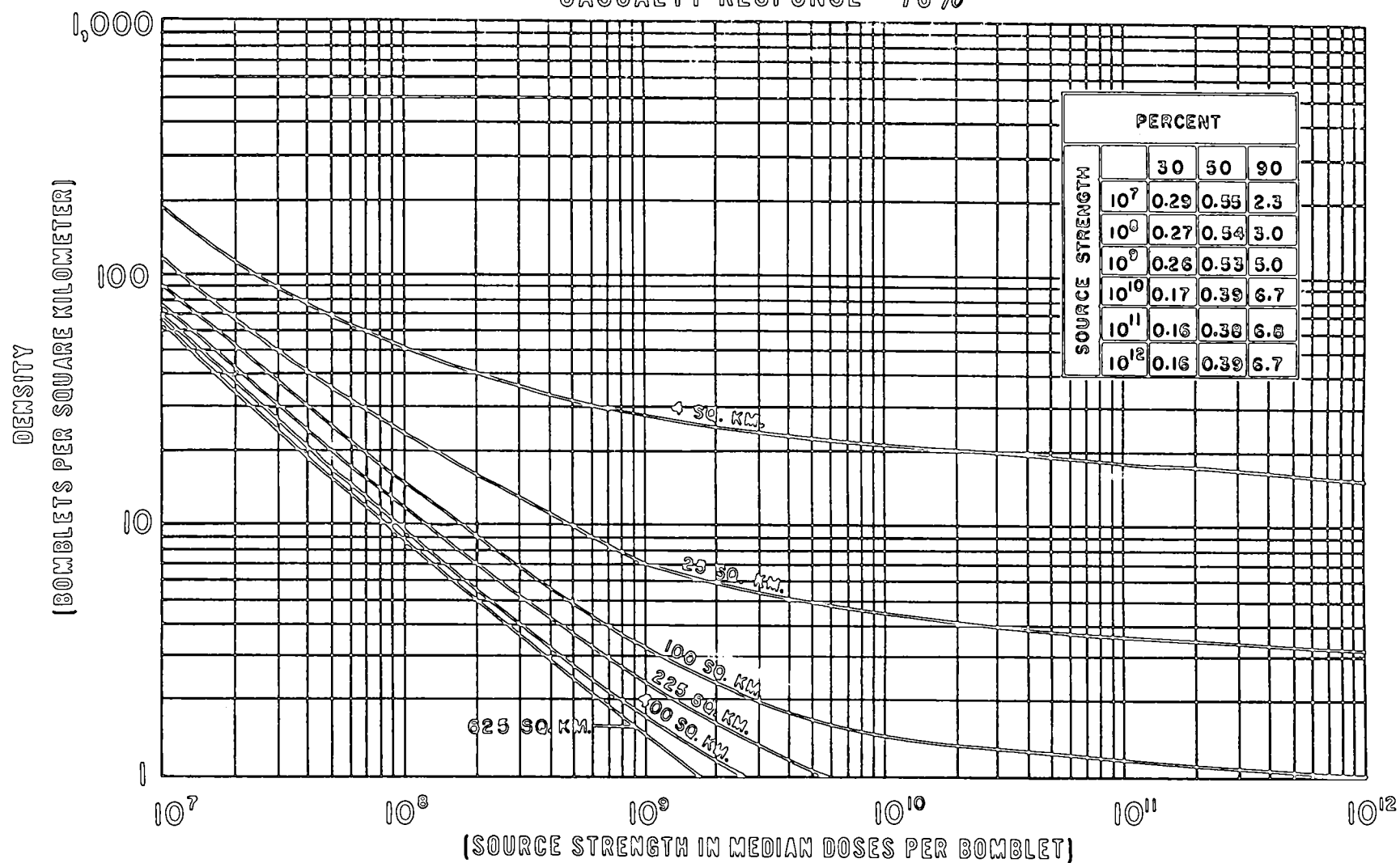


Figure 34. Graph for multiple point source target analysis.

MULTIPLE POINT SOURCE IN AN AREA
BUILT-UP TERRAIN — CONDITION A
DECAY RATE — 0% - 5%
CASUALTY RESPONSE — 70%

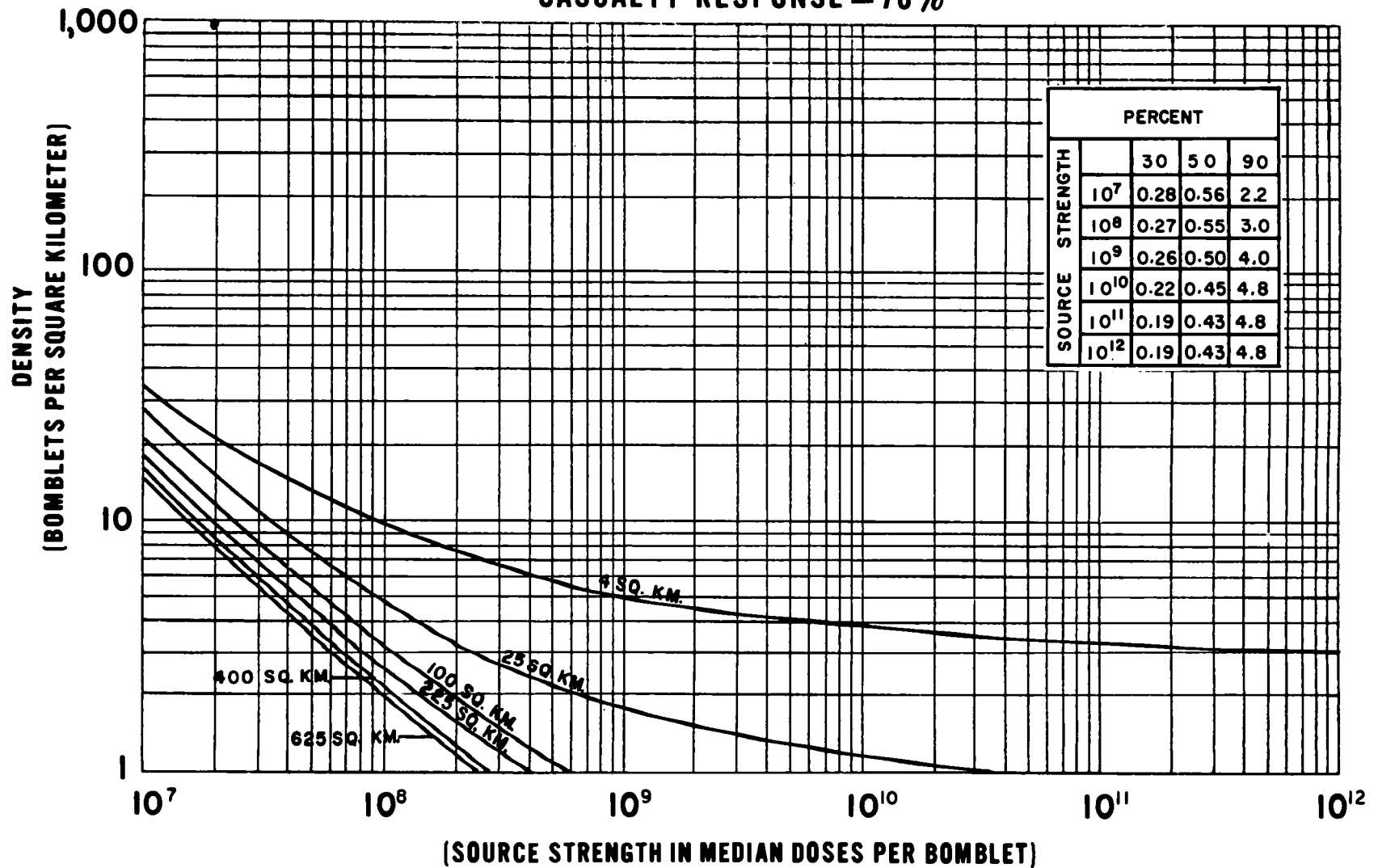


Figure 35. Graph for multiple point source target analysis.

MULTIPLE POINT SOURCE IN AN AREA
 BUILT-UP TERRAIN—CONDITION B
 DECAY RATE—0%-5%
 CASUALTY RESPONSE—70%

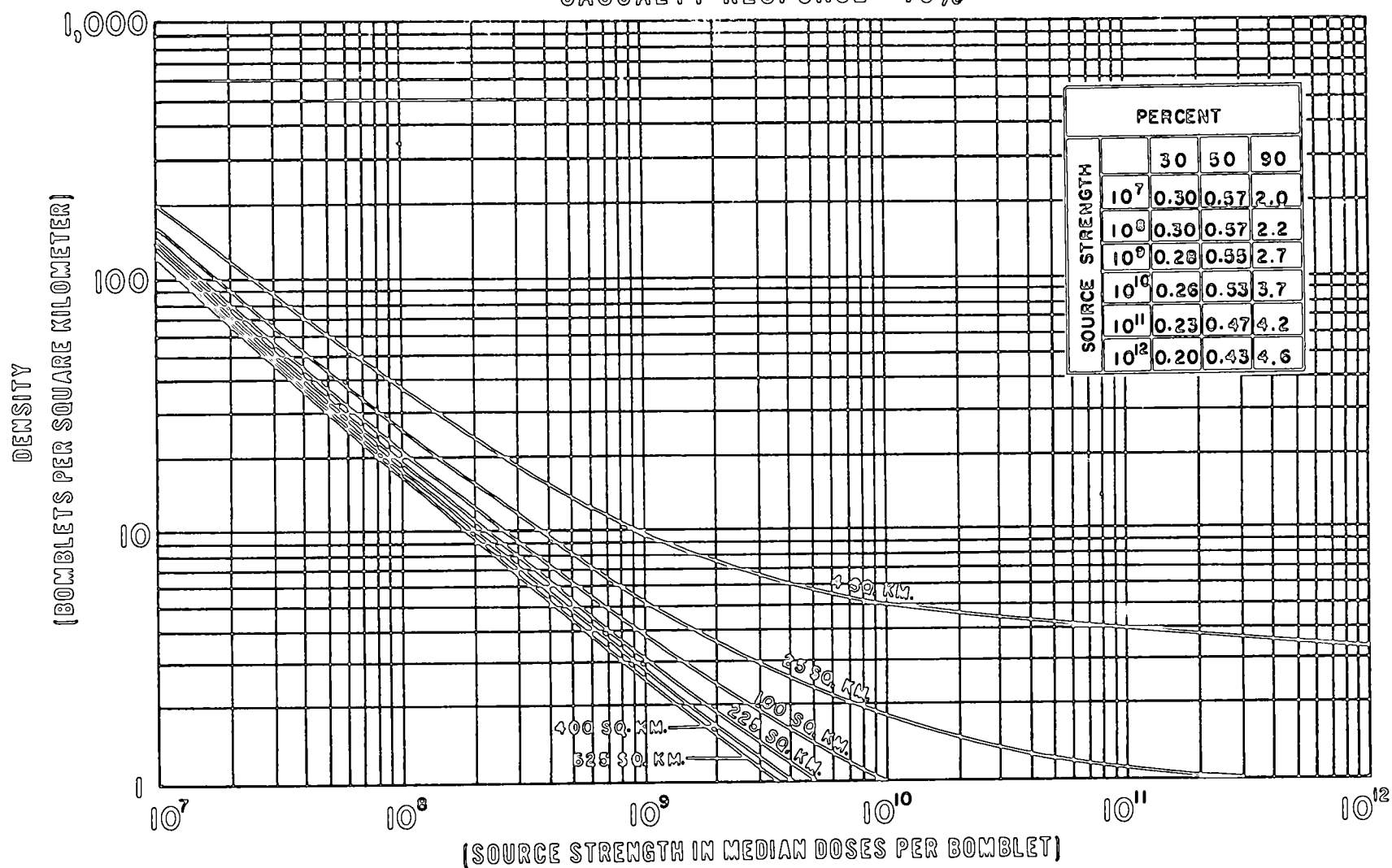


Figure 36. Graph for multiple point source target analysis.

**MULTIPLE POINT SOURCE IN AN AREA
OPEN OR BUILT-UP TERRAIN—CONDITION A
DECAY RATE—20%
CASUALTY RESPONSE—70%**

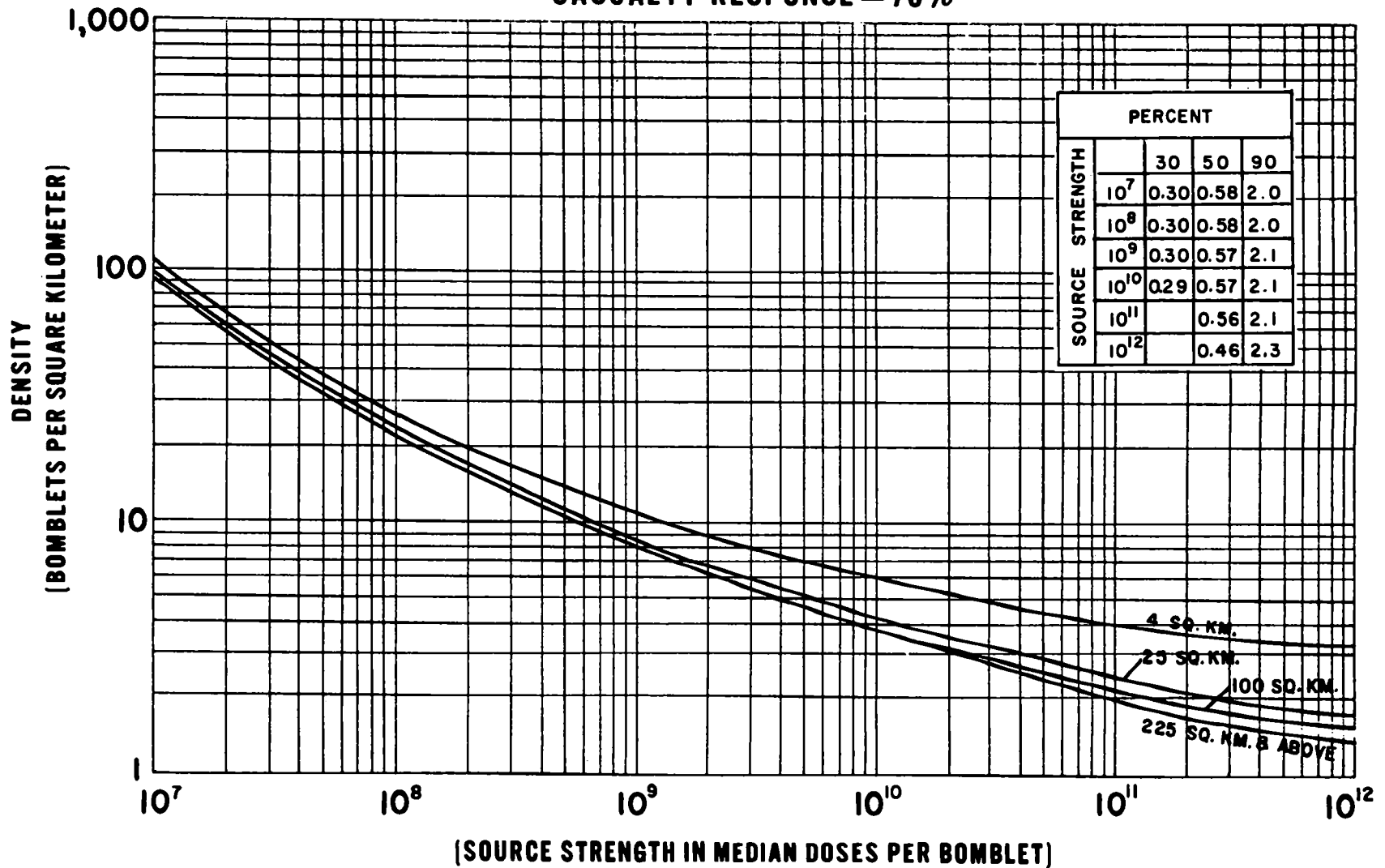


Figure 37. Graph for multiple point source target analysis.

MULTIPLE POINT SOURCE IN AN AREA
OPEN OR BUILT-UP TERRAIN—CONDITION B
DECAY RATE—20%
CASUALTY RESPONSE—70%

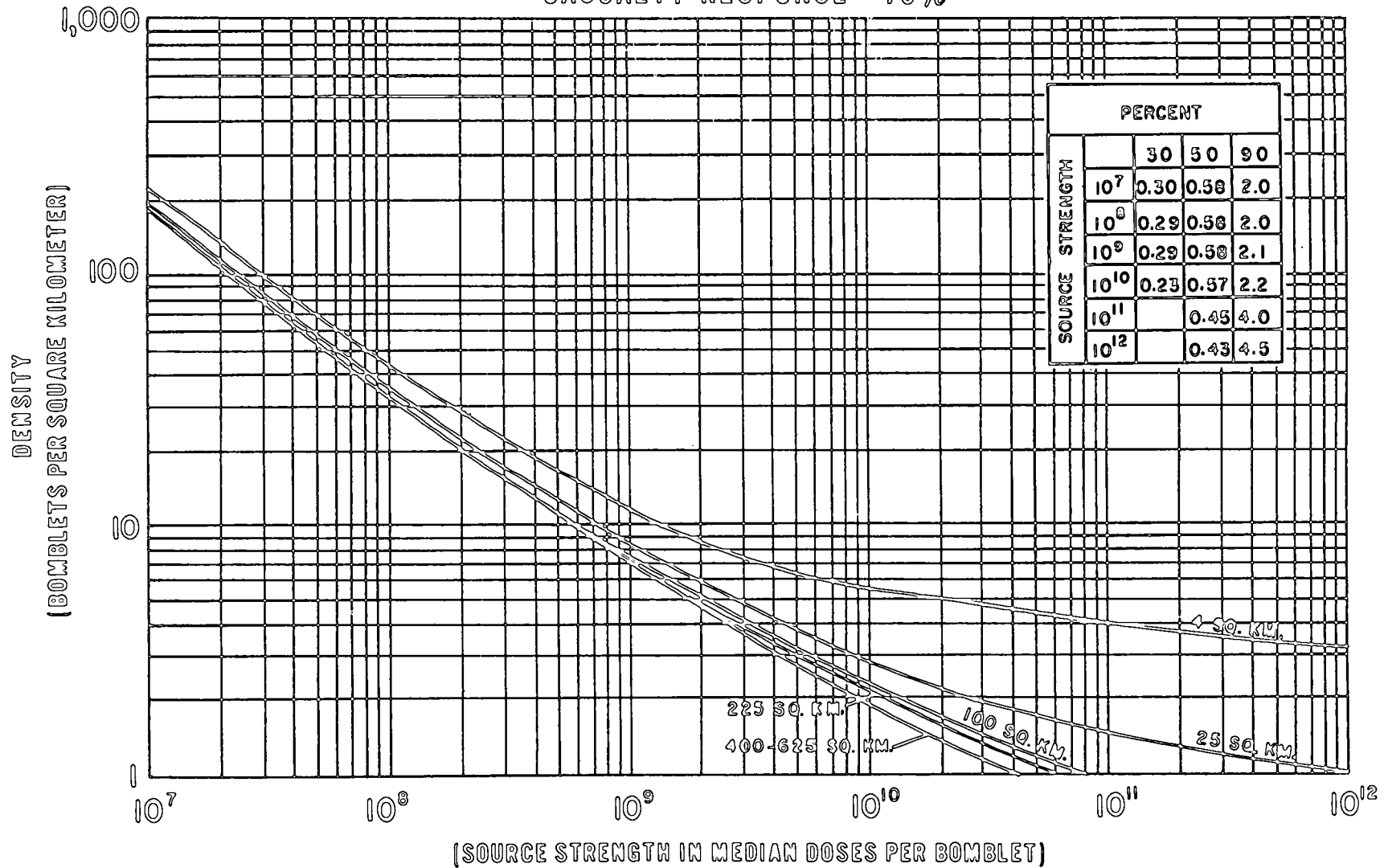


Figure 38. Graph for multiple point source target analysis.

CHAPTER 12

TROOP SAFETY

101. General

The location and vulnerability of friendly forces and friendly civilian populations must be taken into consideration during the planning phases of proposed biological agent employment. Troop safety requirements may influence the selection of an agent, the choice of delivery means, the location and configuration of the projected source, and the time of attack. In general, troop safety calculations are based on the same methods used to determine casualty effectiveness for offensive purposes except for the fact that the minimum source strength, used for computing effects on the enemy, is multiplied by sixteen in calculating troop safety distances.

102. Risk Criteria

a. Factors To Be Considered. The calculated degree of risk to which friendly troops may be exposed requires a command decision. Factors that are considered in arriving at the safety criteria include, but are not limited to:

- (1) Mission.
- (2) Agent.
- (3) Meteorological conditions.
- (4) Terrain.
- (5) Forces disposition.
- (6) Delivery method.
- (7) Delivery system.
- (8) Time of attack.
- (9) Degree of protection.

b. Degree of Risk. The degrees of risk are difficult to define with finality since they must be based ultimately upon the mission and the tactical situation at the time of a biological attack. Only negligible risk is defined. A negligible risk distance is that distance at which 1 percent casualties can be expected among unprotected personnel. A negligible risk is acceptable anywhere the use of biological agents is desirable.

103. Vulnerability

One of the following two conditions of friendly personnel vulnerability can be expected when a biological attack is launched.

a. Unwarned, Exposed. No detector or warning system for determining the presence of biological agent aerosols is available. Therefore, if masks have been issued, personnel are considered exposed unless warned.

b. Warned, Protected. Well-trained troops, if they are warned, will wear the mask. A fraction will fail to benefit from this protection due to mask deficiencies and failure of the individuals to follow approved masking procedure. The degree of such failure will depend on the morale, the state of training, and the discipline of a particular unit.

104. Minimum Safe Distance (MSD)

The minimum safe distance is computed as the sum of an associated risk distance (D) and a buffer distance (d_b):

$$MSD = D + d_b$$

a. The associated risk distance is the distance from the source beyond which the biological weapons effects among friendly troops are considered acceptable. The 1-percent casualty level contour line for unprotected personnel is used for estimating the associated risk distance.

b. The buffer distance is added to the associated risk distance to provide the desired assurance or probability of not exceeding the specified risk. The buffer distance is three times the largest delivery error of the weapon used. The delivery error is obtained from the firing unit. If the delivery error cannot be obtained from the firing unit, the following buffer distances will be used:

- (1) Missiles and rockets: 2,200 meters.
- (2) Bomber release of bomblets: 2,200 meters.

- (3) Spray systems: Manned aircraft, 70 meters; drones, 1,200 meters.

c. The determination of MSD varies according to source configuration.

- (1) *Line source.* Downwind distance from a source to a specified risk level is based on the maximum downwind distance associated with the casualty level coinciding with the acceptable risk. If the commander's acceptable risk is specified as 1 percent casualties, the downwind distance is computed to the 1-percent casualty level contour by means of the methods described in chapter 11. It should be noted that unless correction factors are applied, the distance is for unprotected troops. In calculating downwind distance for troop safety purposes, the source strength used is the *minimum effective source strength multiplied by sixteen*. This allows for the possibility of the agent being fresh rather than being near the specified expiration date concentration. The determination of the risk distance in the case of line release of agent requires consideration of the direction of the release line with respect to friendly troop disposition in addition to wind direction. Figure 39 may be used to determine the correction factor which must be multiplied by the maximum downwind distance as obtained from the appropriate nomograms in chapter 11. This corrected risk distance is measured along the line drawn from the nearest point on the release line to the nearest point of the friendly troop disposition. The angle formed by this line and the release line determines the correction factor applied to the associated risk distance. To obtain the MSD for a particular troop distance, the appropriate d_0 is added to the corrected risk distance. With this information, the area inclosed by the troop safety line for a line source release can be drawn as shown in figure 40.

- (2) *Multiple point source.* The estimation of D for a multiple point source entails the conversion to an equivalent line source. This line source will be of a length equal to the diameter of the

Wind direction in relation to friendly troop disposition	Correction factor applied to associated risk distance
0° (parallel to friendly troops)-----	0. 35
22½°-----	0. 67
45°-----	0. 90
90° (toward friendly troops)-----	1. 00

Figure 39. Wind direction factors for estimating associated risk distance.

bomblet impact area. It is assumed that the line source has been released perpendicular to the wind direction and along a line one-half the radius of the impact area downwind from its center, as shown in figure 41. The total source strength is considered released along this line. After the equivalent line source has been established, the procedures presented in (1) above are followed to obtain the different values of D and MSD. With this information, the area inclosed by the troop safety line can be drawn as shown in figure 41.

105. Safe Entry Time

The following safe entry times are given for an area that has been subjected to a biological agent attack:

Conditions	Safe entry time (hours)			
	Agent UL	Agent OU	Agent NU	Agent AB
Night or overcast day-----	8	18	8	8
Day (sunshine)-----	2	2	2	2

106. Possible Courses of Action When Troop Safety Requirements Cannot be Met

When the distance from friendly troop disposition to the agent release point is less than the minimum safety distance required for the desired degree of risk, one of the following courses of action is adopted:

- Accept a higher degree of risk.
- Change time of attack to a time that affords more favorable conditions.
- Move troop units involved.
- Use a decreased source strength.
- Move release point.
- Use a different agent.
- Increase the protection of the troops involved.

- (1) The commander may decide to order friendly units to don their protective masks in order to reduce the risk.
- (2) In special situations a commander, knowing which biological agents that friendly

forces may employ, can require immunization of friendly troops if vaccines are available and their use is feasible.

h. Use an alternate weapons system to engage the target.

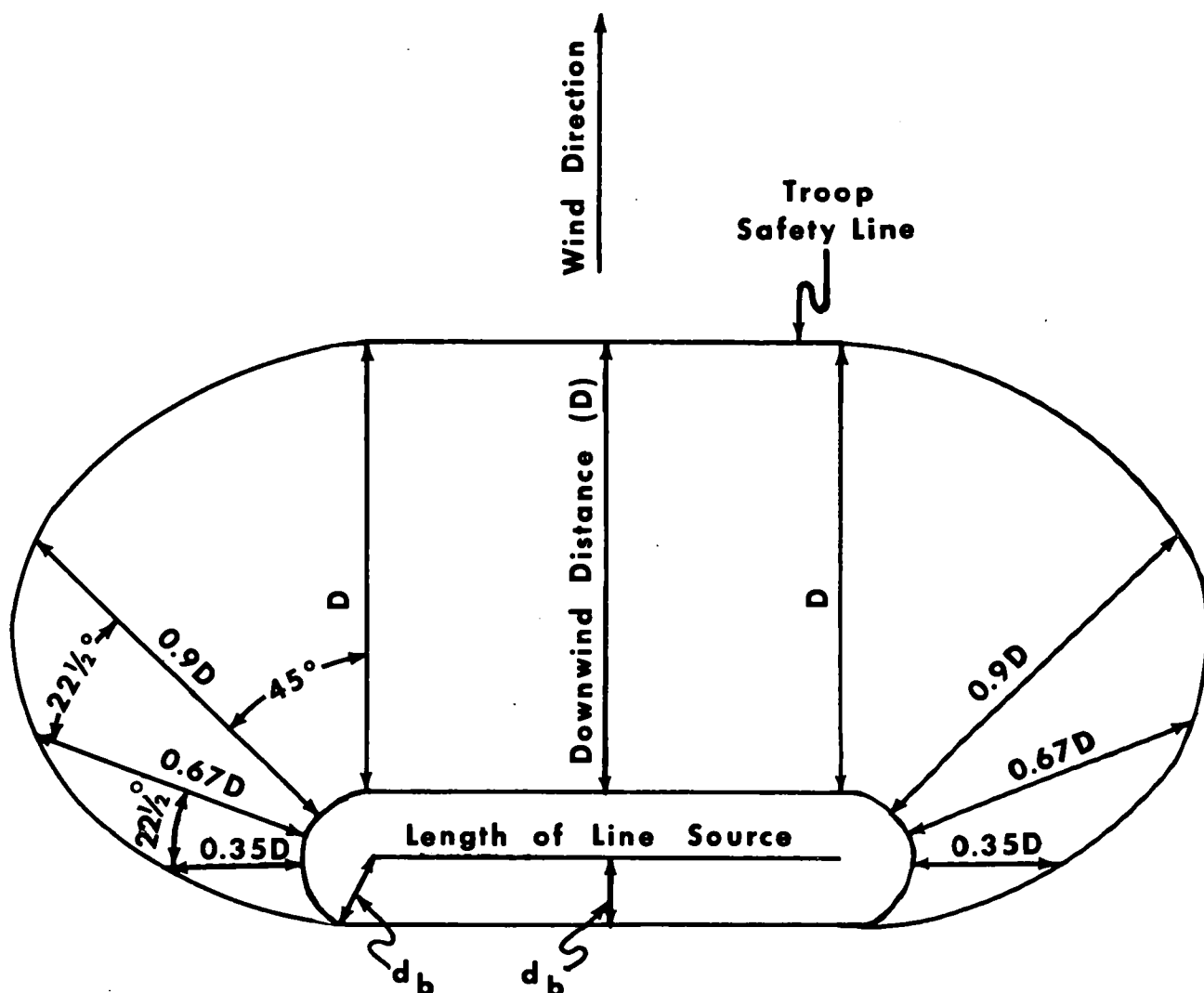


Figure 40. Determination of line source troop safety line from associated risk distance.

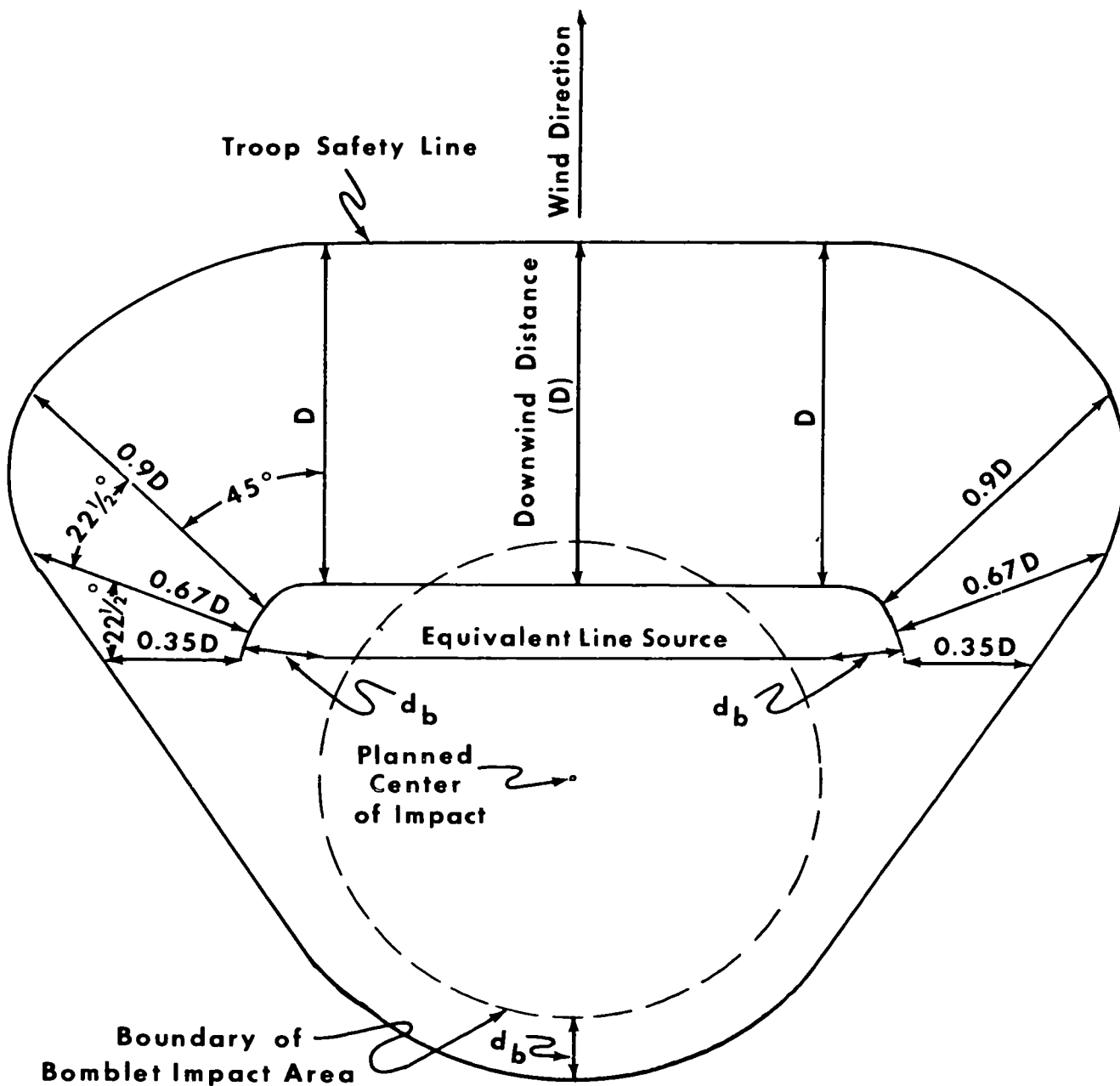


Figure 41. Determination of multiple point source troop safety line from associated risk distance.

CHAPTER 13

COMMAND AND STAFF ACTIONS

Section I. PLANNING

107. General

a. When biological weapons systems under Air Force or Navy control are to be employed in support of ground tactical operations, requests for employment are made by the field army or corps commanders to the Air or Navy Liaison Officer as appropriate.

b. The planning for the tactical employment of biological weapons is done at theater, theater army, field army, and corps levels, for the following reasons:

- (1) The delivery means are under the command of, or in support of, these echelons.
- (2) These levels are the lowest echelons that have the ability to properly coordinate biological attacks.
- (3) The size of target areas affected is such as to require coordination at such levels.
- (4) The characteristic delay in casualty production and the duration of effects are compatible with planning and execution at these levels. The urgency of tactical operations at lower levels does not normally allow for delayed casualty effects.

c. Tactical operations plans are controlled in the tactical operations center (TOC), and administrative support operations are controlled in the administrative support operations center (ADSOC).

108. The Chemical, Biological, and Radiological Element (CBRE)

The CBRE is that part of the chemical special staff section at corps and higher echelons which performs the primary functions of detailed planning of biological operations (and for chemical operations and defensive CBR evaluations). The CBRE is supervised by the chemical officer and is physically located in or adjacent to the fire support element (FSE), a component of the

TOC. Its functions in biological agent employment are:

- a. Detailed planning.
- b. Coordination of plans.
- c. Supervision and coordination of biological surveys.
- d. Evaluation and dissemination of biological effects and contamination data.

109. Commander's Responsibilities

The commanders concerned take positive action to:

- a. Decide on the employment of biological weapons.
- b. Integrate employment with other weapons systems and with scheme of maneuver.
- c. State generally the results desired.
- d. Prescribe troop safety requirements.
- e. Establish limits on the use against civilians.
- f. Provide for the exploitation of effects.
- g. Request tactical support as required from either the Air Force or the Navy.

110. Staff Responsibilities

Based on the planning guidance of the commander, the staff element (CBRE) prepares an estimate of the situation, which is coordinated among all staff sections, but primarily (through the chemical officer) with the G2, G3, and the FSE.

a. G2.

- (1) Collects, processes, and disseminates information on weather pertinent to the employment of biological agents.
- (2) Prepares estimates of enemy susceptibility to biological attack and suggests to G3 targets that may be suitable.
- (3) Estimates, in coordination with chemical officer, the effects of biological attack and residual contamination on friendly operations.

b. G3.

- (1) Integrates the proposed biological plan into the tactical plan.
- (2) Secures target analysis from the chemical officer and integrates it into the operations estimate.
- (3) Designates targets for biological attack and requests the chemical officer for detailed target analysis.
- (4) Proposes integrated and coordinated plan for ground and air delivery.
- (5) Establishes priorities of biological munitions.
- (6) Authenticates the biological annex to the operations order. If a separate biological annex is not prepared, he authenticates the CBR appendix to the fire support plan annex to the operations order.

c. FSE.

- (1) Plans for the direction, control, and coordination of fire support operations.
- (2) Plans for the integration of the fire support provided by other Army elements or elements of the other services.

d. Chemical Officer.

- (1) Advises G3 and the fire support coordinator on the employment of biological munitions.
- (2) Prepares target analyses (with CBRE) to include the type and number of munitions required and the extent and duration of effects.
- (3) Prepares the biological annex to the operations plan. (This annex may be a part of the CBR appendix to the fire support plan.)
- (4) Coordinates the CBR plan.
- (5) Determines the biological munitions requirements.
- (6) Advises on measures to be taken for troop safety.

e. G4.

- (1) Assures that the biological annex of the operations plan can be supported.
- (2) Determines from G3 the areas to be affected by the attack and plans the location of logistical installations, supply routes, and administrative support areas accordingly.
- (3) Insures that traffic control plans be prepared in consonance with operations plans.

- (4) Allocates biological munitions in accordance with priorities established by G3.

f. G1.

- (1) Plans the location of personnel installations in consonance with operations plans and troop safety considerations.
- (2) Estimates effects of biological operations on morale, law and order, and discipline of the command.

g. G5.

- (1) Estimates effects of biological attack on civilian populations.
- (2) Estimates the military support required for civilian populations.

h. Other Staff Officers.

- (1) *Surgeon*—Estimates required medical supplies and insures their availability; plans for medical installations and units, and facilities for handling casualties; advises on defensive medical aspects of biological agent employment.
- (2) *Transportation Officer*—In coordination with G4 and the provost marshal, prepares traffic regulations and circulation plans to minimize the effects of operations on friendly units.
- (3) *Quartermaster*—Plans for handling of contaminated dead and for storage and issue of protective clothing.
- (4) *Ordnance*—Advises G3 on availability of Army biological munitions.
- (5) *Provost Marshal*—In coordination with G4 and transportation officer, prepares the traffic control plan.
- (6) *Engineer*—Establishes the requirement for engineer support.
- (7) *Staff Weather Officer*—Coordinates with G2 to provide pertinent weather data.

111. Commander's Estimate, Decision, and Concept

Based upon the staff estimate and the target analyses, the commander revises where necessary his planning guidance so as to be in consonance with capabilities and predicted effects. Such revision may involve:

- a. Acceptance of reduced casualty level.
- b. Acceptance of higher degrees of risk to friendly troops.
- c. Revision of scheduled times of attack.
- d. Movement of friendly units.
- e. Displacement of agent release points.

f. Adoption of a different agent or delivery means.

g. Improvement of troop protection criteria.

h. Decision not to employ biological agents in particular situations.

112. Staff Planning Phase

When the commander's estimate, decision, and concept of operation are received, the staff prepares the necessary plans for biological attack. If the decision differs from the actions developed by G3 or if initial contingent requirements are changed, additional detailed target analyses are performed and incorporated into the continuing staff estimates and the tactical plan.

Section II. BIOLOGICAL AMMUNITION SUPPLY

115. Control of Biological Weapons

a. Within the limitations imposed by production, transportation, and storage capabilities, and in accordance with approved war plans, the Joint Chiefs of Staff control the strategic allocation and dispersal of biological agents and weapons to theaters of operation, maintaining adequate reserves or controlled production outputs in the continental United States. The theater commander further suballocates to component commanders, based on combat requirements, and retains a portion of his allocation for a theater reserve. The theater allocation to theater army will include weapons to be delivered by Air Force and Navy components. They are suballocated by the theater army commander to his major commands and are not allocated lower than corps.

b. Biological administrative support and control consists of supply, maintenance, decontamination, laboratory service (limited), intelligence, and miscellaneous services such as escort, demilitarization, and disposal. G4 plans the logistical organization and operations so as to insure provision of uninterrupted logistical support of the operation. In addition to normal precautions, he will make provisions for handling biological munitions and supporting equipment as required. In coordination with G3, the G4 provides necessary security for biological weapons in logistical channels.

113. Execution Phase

The culmination of the staff actions is the issuance of an order and the supervision of its execution. The execution phase may consist of:

a. Revision of effects estimates and safety considerations to exploit unforeseen favorable developments or to protect against unfavorable ones.

b. Revision of execution plans to take advantage of tactical opportunity.

114. Poststrike Analysis

The intelligence officer, in coordination with the chemical officer, will gather and interpret information concerning the attack after its completion. An analysis of this information is prepared and distributed by the intelligence officer.

116. Allocation

Each major commander will be furnished an allocation in accordance with primary and alternate plans.

a. Allocations are made in terms of delivery system and agent.

b. A commander who receives an allocation is given authority to specify the time and place for delivery, subject to restrictions imposed by higher headquarters and normal coordination procedures.

c. A commander who suballocates weapons to a subordinate command may withdraw or change that allocation.

d. The delivery means may or may not be under the control of the commander receiving the allocation.

117. Storage-to-Target Sequence

a. Figures 42 and 43 illustrate the typical schematic sequence for movement of biological weapons from a production facility to the user. The logistics system uses all methods currently available to transport biological materials. The channels used to accomplish emergency and routine supply and resupply are so labeled.

b. Biological weapons follow a production-to-storage-to-target sequence that involves brief storage in CONUS stockpiles, transportation to

and within overseas theaters of operation, and subsequent use.

c. Biological munitions and containers will be filled at the CONUS source. These will then be sealed in a shipping case. Biological munitions and containers may be moved in refrigerated trailers that can be rigged for air, rail, truck, or shipboard transport. Such vans are available and

represent a working solution to the problem of temperature-controlled storage during transit. Airlift of biological munitions from the point of assembly to the operation or strike base will be normal and will simplify logistics within the theater of operations. FM 3-10A contains information on storage, surveillance, issue and logistical support for biological munitions.

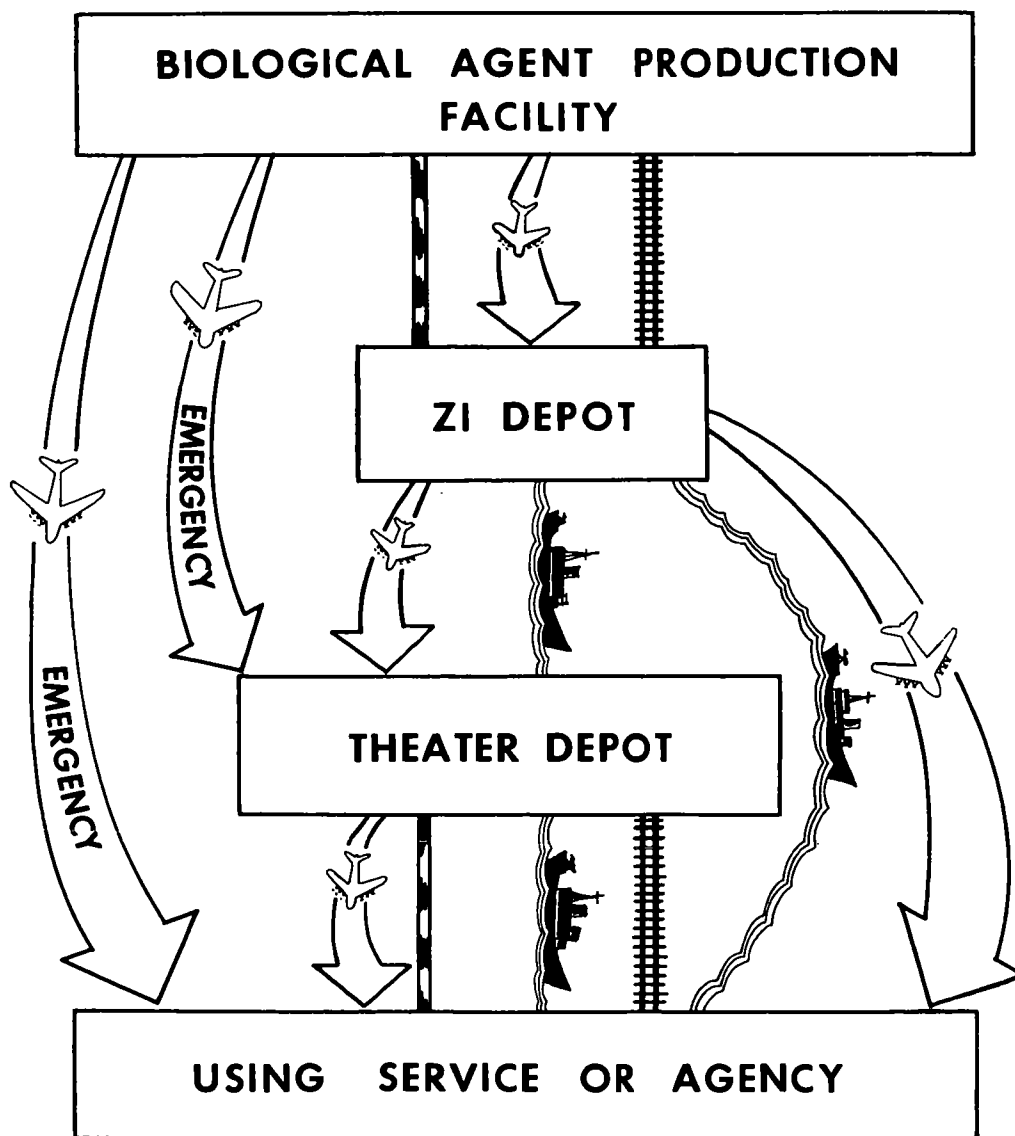


Figure 42. Biological munition supply sequence.

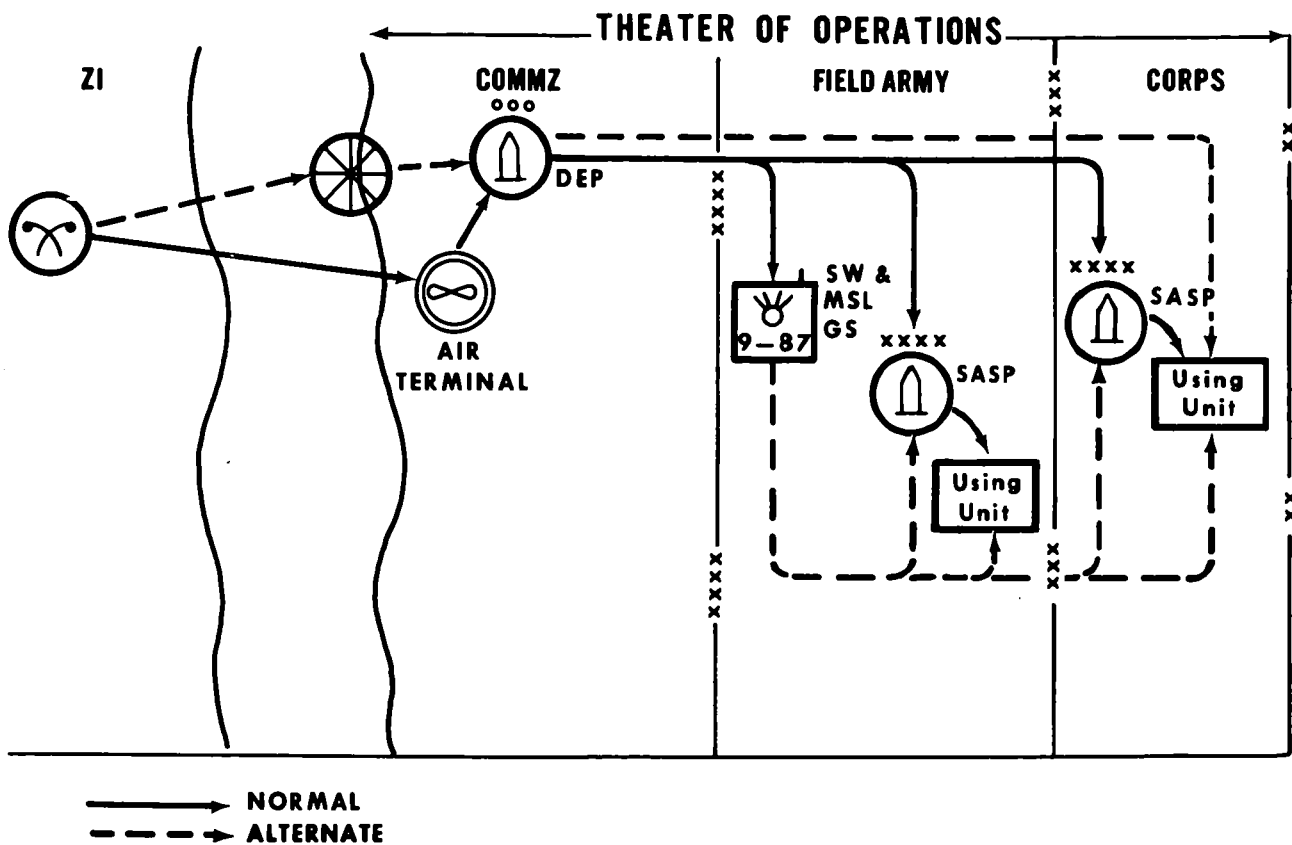


Figure 43. Flow of biological munitions.

APPENDIX I

REFERENCES

AR 320-5	Dictionary of United States Army Terms
AR 320-50	Authorized Abbreviations and Brevity Codes
AR 700-62	Chemical Protective Clothing Policy and Utilization of Certain Chemical Corps Units and Equipment in Combat Area (U).
FM 3-5	Chemical, Biological, and Radiological (CBR) Operations
FM 6-20	Field Artillery Tactics and Techniques
FM 6-40	Field Artillery Cannon Gunnery
FM 9-5	Ordnance Ammunition Service
FM 21-5	Military Training
FM 21-6	Techniques of Military Instruction
FM 21-30	Military Symbols
FM 23-30	Grenades and Pyrotechnics
FM 31-10	Barriers and Denial Operations
FM 101-5	Staff Officers' Field Manual: Staff Organization and Procedure
FM 101-31	Staff Officers' Field Manual: Nuclear Weapons Employment (U)
TC 3-7	Capabilities and Employment of Biological Agents (U)
TM 3-200	Capabilities and Employment of Toxic Chemicals
TM 3-215	Military Chemistry and Chemical Agents
TM 3-216	Military Biology and Biological Agents
TM 3-240	Field Behavior of Chemical Agents
TM 3-250	Storage, Shipment, and Handling of Chemical Agents and Hazardous Chemicals
TM 3-300	Ground Chemical Munitions
TM 3-304	Protective Clothing and Accessories
TM 3-400	Chemical Bombs and Clusters
TM 9-1950	Rockets
DA Pam 39-1	Nuclear Weapons Employment
DA Pam 108-1	Index of Motion Pictures, Filmstrips, Slides, and Phono-Recordings
DA Pam 310-1	Index of Administrative Publications
DA Pam 310-3	Index of Training Publications
DA Pam 310-4	Index of Technical Manuals, Technical Bulletins, Supply Bulletins, Lubrication Orders, and Modification Work Orders.
DA Pam 310-7	Index of Tables of Organization and Equipment, Type Tables of Distribution, and Tables of Allowances.

APPENDIX II

SAMPLE FORMAT

CBR WEATHER FORECAST

	Date/Time _____
	Valid (F _t) _____
1. Area Forecasted—Division Area of Influence	
	F _t F _t +3 Hr F _t +6 Hr
2. Wind—ddff (nearest 10°, knot) for:	
a. at 2 meters	
or 3 feet	
b. At 100 meters	
or 300 feet	
3. T _{2m} —T _{½m}	
or T _{8ft} —T _{1ft}	
(0, ±1°F, ±2 °F, or ±3°F)	
4. Temperature	
(°F.)	
5. Relative Humidity	
(nearest 5%)	
6. Precipitation	
(rain or snow)	
(light, moderate, heavy)	
7. Visibility	
8. Cloud cover (clear,	
scattered, broken,	
overcast) and Height	
(Low <1000ft or 300m)	
(Medium <5000ft or 1500m)	
(High ≥5000ft or 1500m)	
9. Isolation (sunshine)	
(yes or no)	
10. Fallout winds	
(F _t thru F _t +6Hr)	
(Altitude, direction and speed)	

APPENDIX III

CONVERSION SCALES

Conversion Scales

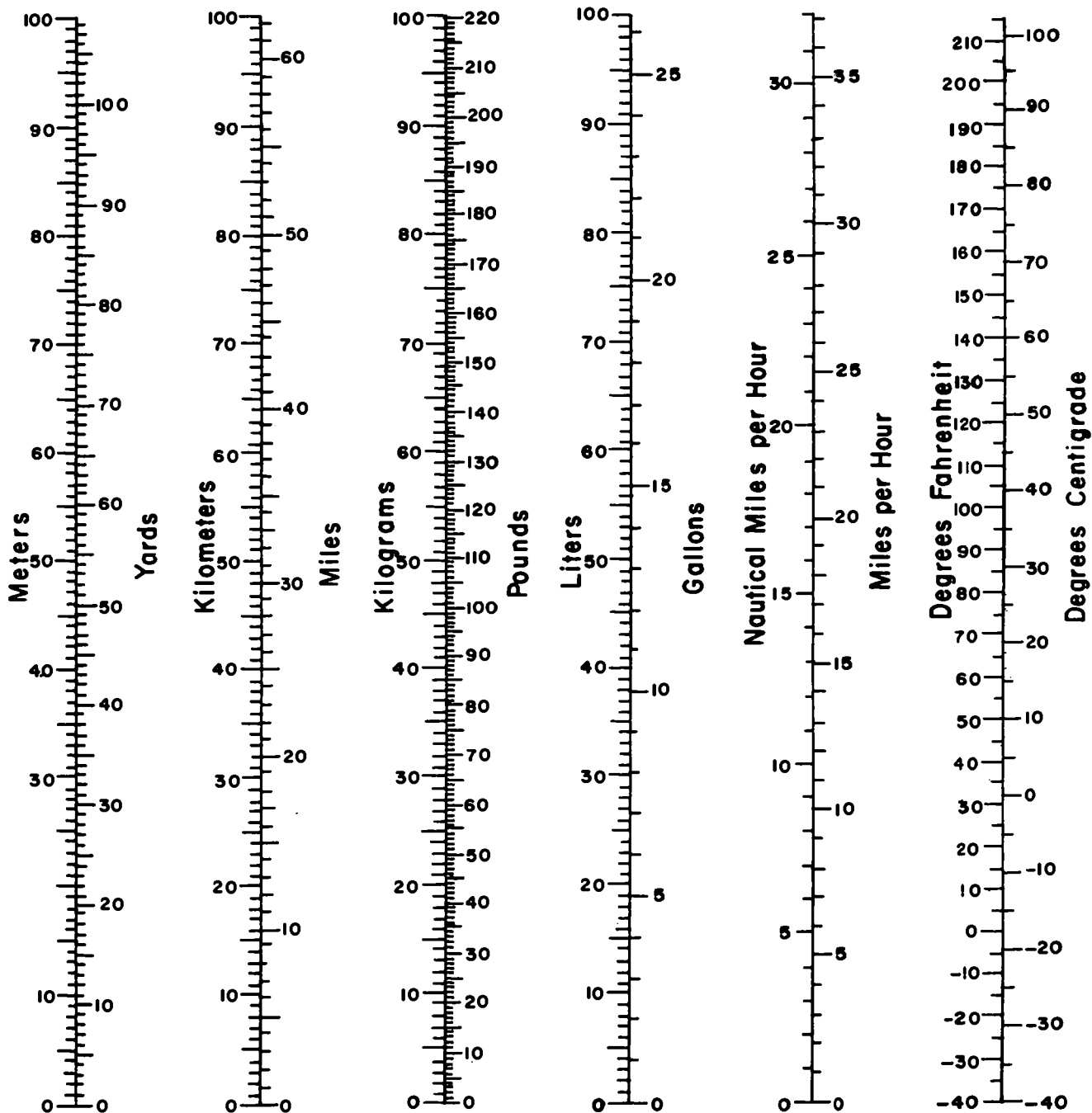


Figure 44. Conversion scales.

APPENDIX IV

FORMAT FOR CHEMICAL TARGET ANALYSIS

Reference: Give maps, title, and scale.

1. **MISSION.** State the purpose of the chemical attack.
2. **SITUATION.** Describe the targets and all factors affecting the selection of targets for attack with toxic chemical agent.
 - a. *Situation of Opposing Forces.*
 - (1) *Enemy situation.* List information that will aid in analysis of proposed targets.
 - (2) *Friendly situation.* List information that will aid in analysis of proposed situation. State the effect of chemicals on the unit mission and plan of operations.
 - b. *Target Characteristics.*
 - (1) *Composition.* Describe the composition of the target as personnel or materiel and installations.
 - (2) *Location.* State the location of the target in relation to friendly troops, friendly indigenous personnel, and possible delivery systems.
 - (3) *Target size and shape.* Determine the general shape of the target and its size in hectares.
 - (4) *Permanence.* State whether the target is a temporary one.
 - (5) *Level of protection.* Consider the degree of susceptibility to the agent.
 - c. *Target Capabilities.* Discuss the capability of the target to affect the accomplishment of the unit mission.
 - d. *Other Factors.* Discuss any or all of the following factors which are pertinent to the situation:
 - (1) *Creation of obstacles.* Consider whether resulting contamination will create obstacles to the friendly plan of maneuver.
 - (2) *Surprise.* Consider measures available for obtaining surprise.
 - (3) *Delay in casualty production.* Discuss acceptable delay and its influence on agent selection.
 - e. *Means of Attack.* Consider available means of delivery and ammunition requirements. Indicate the most practicable delivery means.
3. **ANALYSIS.** Discuss each means of chemical attack in relation to target characteristics and other factors.
4. **EVALUATION AND CONCLUSIONS.** Consider the advantages and disadvantages of each means of attack and decide which will best assist the commander in accomplishing his unit's mission.
5. **RECOMMENDATION.** State the recommended plan for the chemical attack to include:
 - a. Location and type of targets.
 - b. Chemical agents to be used.
 - c. Type of unit to deliver the agent and the amount required.
 - d. Time of attack.
 - e. Time limitations for completion of delivery.
 - f. Troop safety measures and coordination required.
 - g. Poststrike analysis request.

APPENDIX V

EXAMPLE ANALYSIS OF CHEMICAL TARGETS

1. This appendix illustrates some procedures that could be used in the analysis of targets under consideration for attack with chemical agents. For the sake of brevity, several of the steps involved have been omitted, the main emphasis being placed on the construction of a flow chart for the targets being analyzed and the determination of meteorological effects on chemical agent clouds.
2. In the particular situation given, it has been decided to employ surprise attack dosages so as to build up high concentrations as rapidly as possible. It also has been decided that, so far as possible, the chemical missions will be fired simultaneously.
3. Adjustment of the wind speed in discrete target areas is based on the guidance given in TM 3-240. The same manual was used to estimate the wind vectors in the general target area at the time of attack and the hours thereafter.
4. The computation of distance traveled by a chemical agent cloud has been based on the estimated wind vectors at the times concerned.
5. A dosage of 5 mg-min/m³ has been used as negligible risk criteria. In the computation of new downwind distances after a change in the predicted meteorological condition at subsequent times, it has been assumed that the entire quantity of agent originally disseminated has moved downwind and that the source strength is unchanged. New downwind distances were then computed using the new meteorological data.

Copy No. _____
 20th Inf Div
 Cotta (801 160)
 180500 June

Reference: Special Map A (fig. 45).

1. MISSION—Division Attacks 200700 June—To seize objective COBRA. Prepare to continue attack on order.
2. SITUATION
 - a. Situation of opposing forces:
 - (1) Enemy: overlay #1.
 - (2) Friendly: overlay #2.
 - b. Target characteristics—Annex A.
 - c. Target capabilities—Annex A.
 - d. Type and time of attack: Annex A.
 - e. Terrain and weather:
 - (1) Terrain: Broken hills and intermittent vegetation.
 - (2) Predicted meteorological conditions:

	200500	200600	200700	200800	200900	201000
Temperature ° F.	70	72	72	74	80	85
	Inversion	Inversion	Neutral	Lapse	Lapse	Lapse
Temperature Gradient	+2	+1		-1	-2	-3
Prevailing Wind Speed (km/hr)	13	13	16	19	19	22
Wind Direction—Given in wind vector overlays.						

3. ANALYSIS (omitted).
4. EVALUATION AND CONCLUSIONS (omitted).
5. RECOMMENDATION (omitted).

ANNEX A TO APPENDIX V

Target identification No.	Concentration No. (if attacked)	Composition	Location (overlay 1) ¹	Size in hectares	Shape (overlay 1) ¹	Permanence	Level of protection ²
1		Rifle Co		45	Rectangle	Static	Dug-in; Masks Aval
2		Rifle Co		75	Rectangle	Static	Dug-in; Masks Aval
3		Rifle Co		45	Rectangle	Static	Dug-in; Masks Aval
4		Rifle Plat		7	Rectangle	Static	Dug-in; Masks Aval
5		Rifle Plat		7	Rectangle	Static	Dug-in; Masks Aval
6		Rifle Co		30	½-circle	Static	Dug-in; Masks Aval
7		Rifle Co		45	Rectangle	Static	Dug-in; Masks Aval
8		Tank Unit		50	Ellipse	Mobile	Dug-in; Masks Aval
9		Arty Btry		10	Ellipse	Mobile	Dug-in; Masks Aval
10		Arty Btry		10	Ellipse	Mobile	Dug-in; Masks Aval
11		Arty Bn		20	Ellipse	Mobile	Dug-in; Masks Aval
12		Arty Bn		20	Ellipse	Mobile	Dug-in; Masks Aval
13		Mech Bn		250	Ellipse	Mobile	Dug-in; Masks Aval

Target identification No.	Target capability	Tentative priority for attack	Effect desired	Time for completion of delivery	Agent	Minimum amount of agent required (35% Casualty level)	
						155-mm Rounds	Kilograms
1	Atk flank of 2/62 Inf	3	Nonpersistent	30-sec	GB	100	296
2	Block 2/62 Inf	1	Nonpersistent	30-sec	GB	170	500
3	Block 3/63 Inf	2	Nonpersistent	30-sec	GB	100	296
4	Delay 3/63 Inf	12	Nonpersistent	30-sec	GB	18	52
5	Delay 3/63 Inf	13	Nonpersistent	30-sec	GB	18	52
6	Block Adv of 3/63 Inf	7	Nonpersistent	30-sec	GB	70	207
7	Block Adv of 2/62 Inf	6	Nonpersistent	30-sec	GB	100	296
8	Atk 3/63 or 2/62 Inf	4	Nonpersistent	30-sec	GB	60	180
9	Delay by fire	10	Persistent	10-min	HD	22	65
10	Delay by fire	11	Nonpersistent	30-sec minimum	GB	23	68
11	Delay by fire	8	Nonpersistent	30-sec minimum	GB	45	133
12	Delay by fire	9	Persistent	10-min	HD	44	130
13	Atk in Div Zone	5	Nonpersistent	30-sec	GB	600	177

¹ For location of numbered target, see overlay 1.

² Personnel in armored vehicles are considered dug-in.

ANNEX A TO APPENDIX V—Continued

Target Identification No.	Approximate cross-wind diameter of target covered (meters)	Effective source strength (kg/meter)	Adjusted wind speed in target area at 0600 hr (km/hr)	Time of chemical attack	Maximum downwind distance (km) (See Overlay 3 through 9)				
					0600	0700	0800	0900	1000
1	500	0.592	10	N/A					
2	800	.625	13	0600	40	13	2		
3	400	.74	13	0600	28	10	1.8		
4	400	.13	13	0600	6	2	.4		
5	400	.13	8	0600	6	2	.4		
6	600	.35	8	0600	18	5	1		
7	1200	.25	8	0600	12	4	.8		
8	1000	.18	8	0600	9	3	.6		
9	500	.13	8	0610	Limited				
10	500	.14	10	0610	6	2	.4		
11	1000	.13	10	0610	5	1.7	.4		
12	1000	.13	5	0610	Limited				
13	1000	.83	6	0600	80	27	6	.5	Dissipated

ID No.	Estimated cloud travel from 0600 to 1000 hrs based on estimated wind vectors, terrain, and temperature gradient ¹ (km)				Available batteries or sorties within range of target	Weapon recommended for employment on target
	0600 to 0700	0700 to 0800	0800 to 0900	0900 to 1000		
1	10-14 SSE				Determined by coordination with the Fire Support Coordinator for all targets.	Other than Cml
2	10-13 SSE	10-13 SSE	Dissipated			3 M91 lchr
3	10-13 SSE	10-13 SSE	Dissipated			3 M91 lchr
4	10-13 SSE	5-8 SSE	Dissipated			2 105 btry
5	6-8 S	Dissipated				1 155 btry
6	7-10 S	7-10 SSE	Dissipated			3 How. bn
7	5-8 SW	5-8 S	Dissipated			3 M91 lchr
8	5-8 W	Still	Dissipated			1 155 btry
9	Not applicable					1 155 btry
10	5-8 W	Still	Dissipated			Other than Cml
11	5-8 W	Dissipated				Other than Cml
12	Not applicable					2 8-in. btry
13	5-8 W	Still	3-6 E	Dissipated		2 HONEST JOHNS

¹ Estimates are obtained from a meteorological and terrain study of the target area. See overlays 3, 4, 5, and 6.

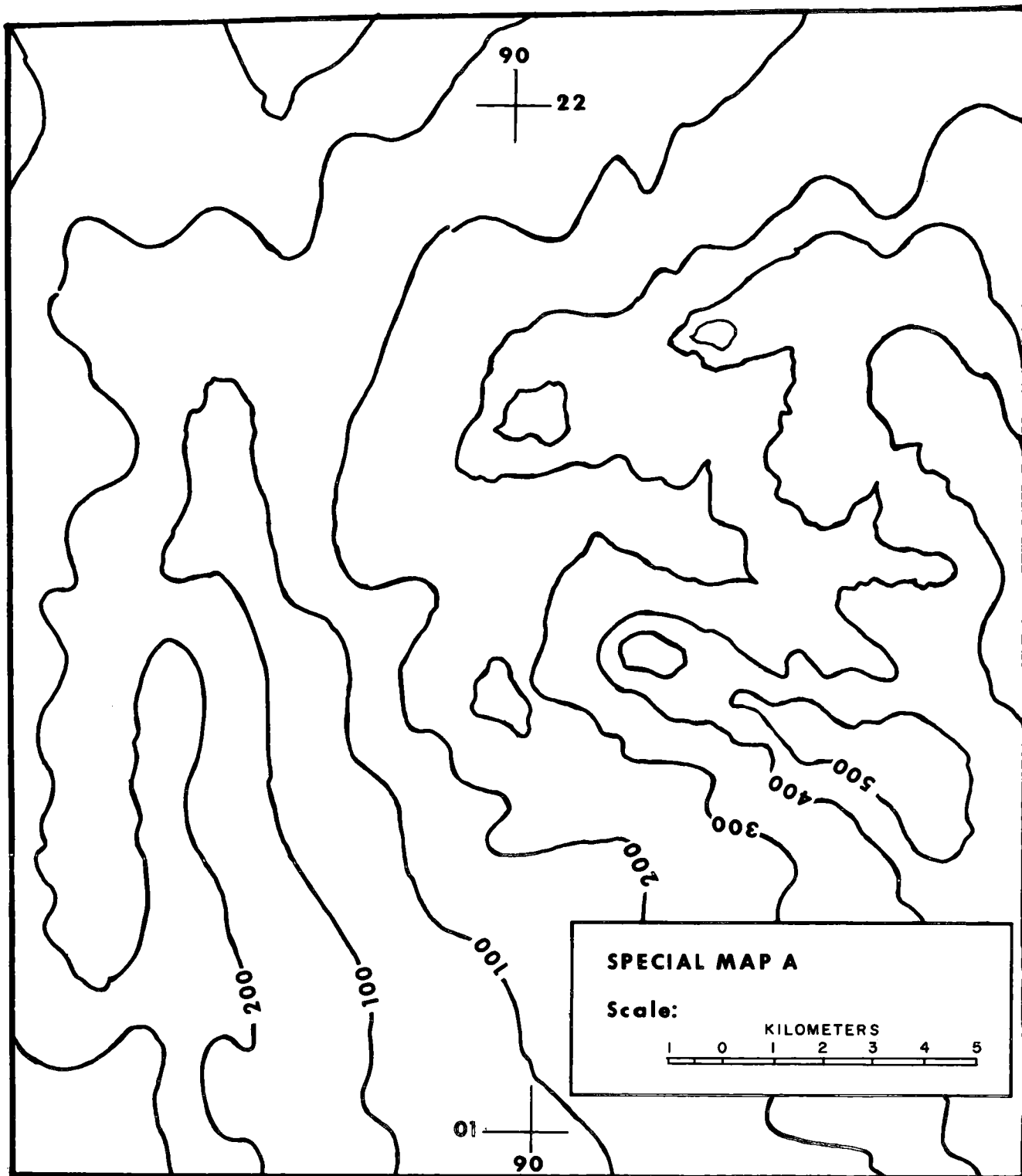


Figure 45. Special Map A.

14

22 — 90 —

12

1

7

2

10

13

8

11

6

3

9

5

4

Overlay 1

ENEMY SITUATION

Map: Special Map A

01 — 90 —

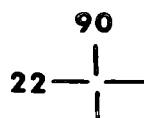
1 Enemy situation

Figure 45.—Continued.

0700

LD

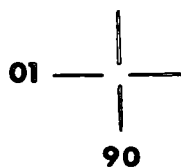
1/61
AXIS OF ADVANCE



2/62
AXIS OF ADVANCE

3/63
AXIS OF ADVANCE

LD
0700

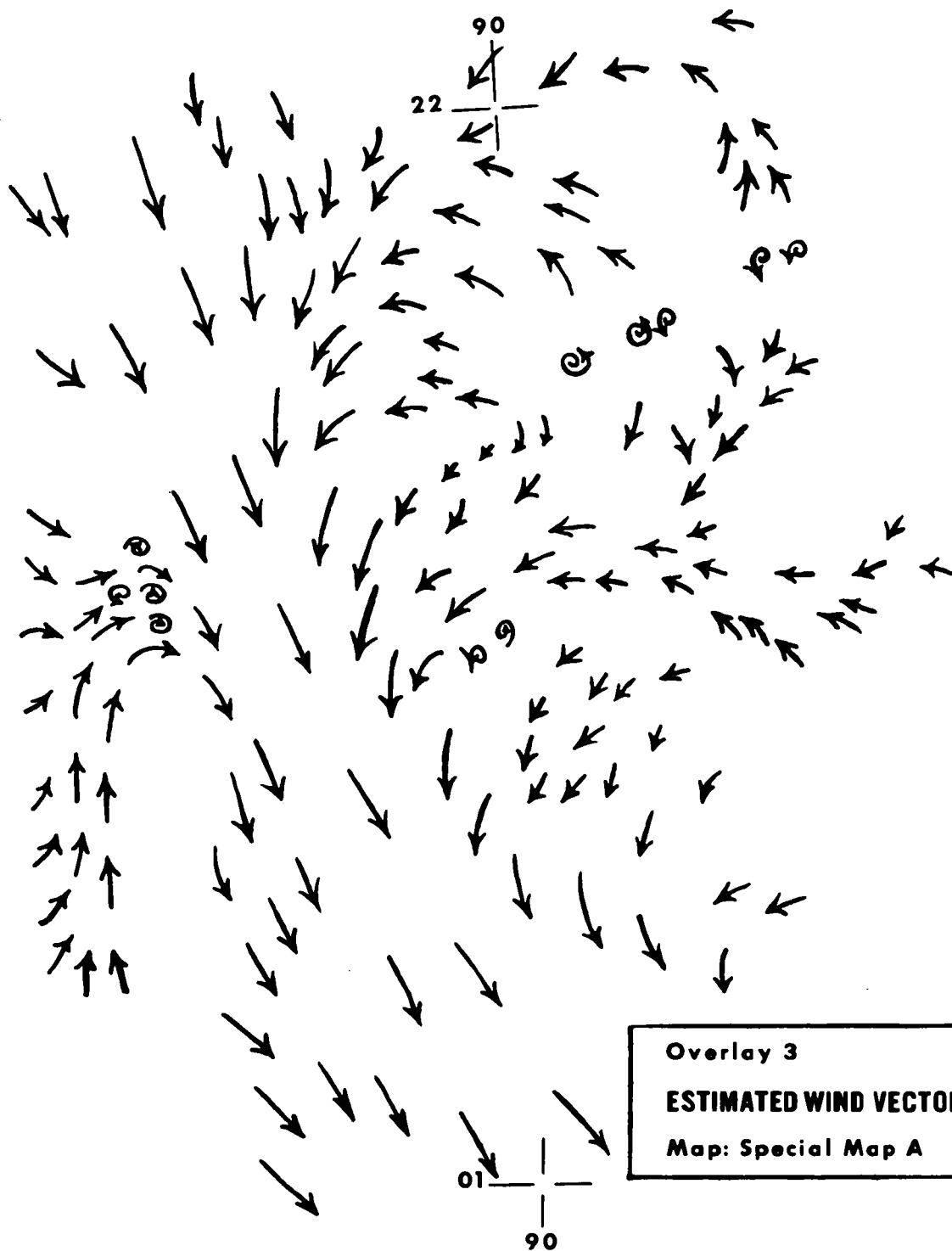


Overlay 2

FRIENDLY PLAN OF MANEUVER

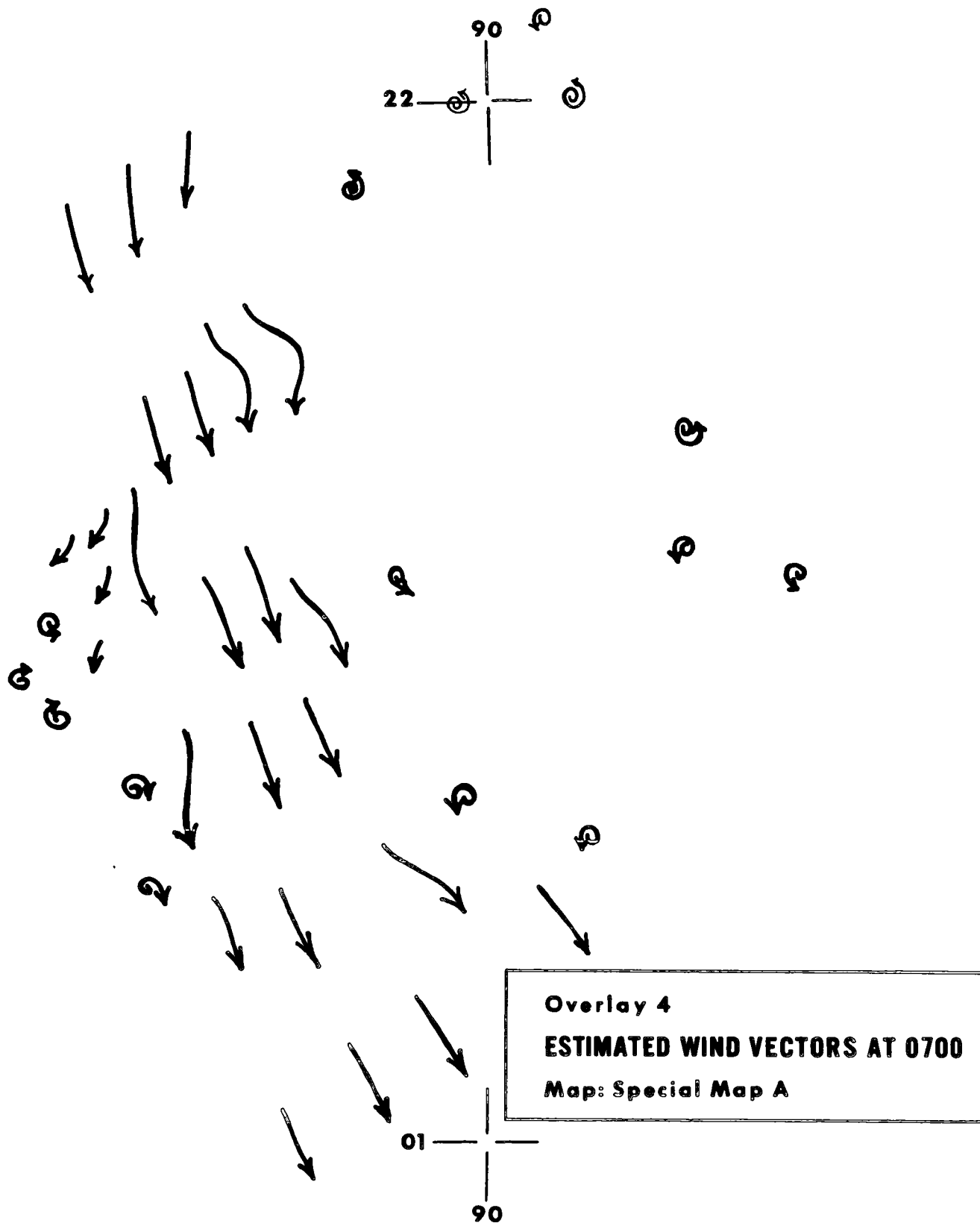
Map: Special Map A

2 Friendly plan of maneuver
Figure 45.—Continued.



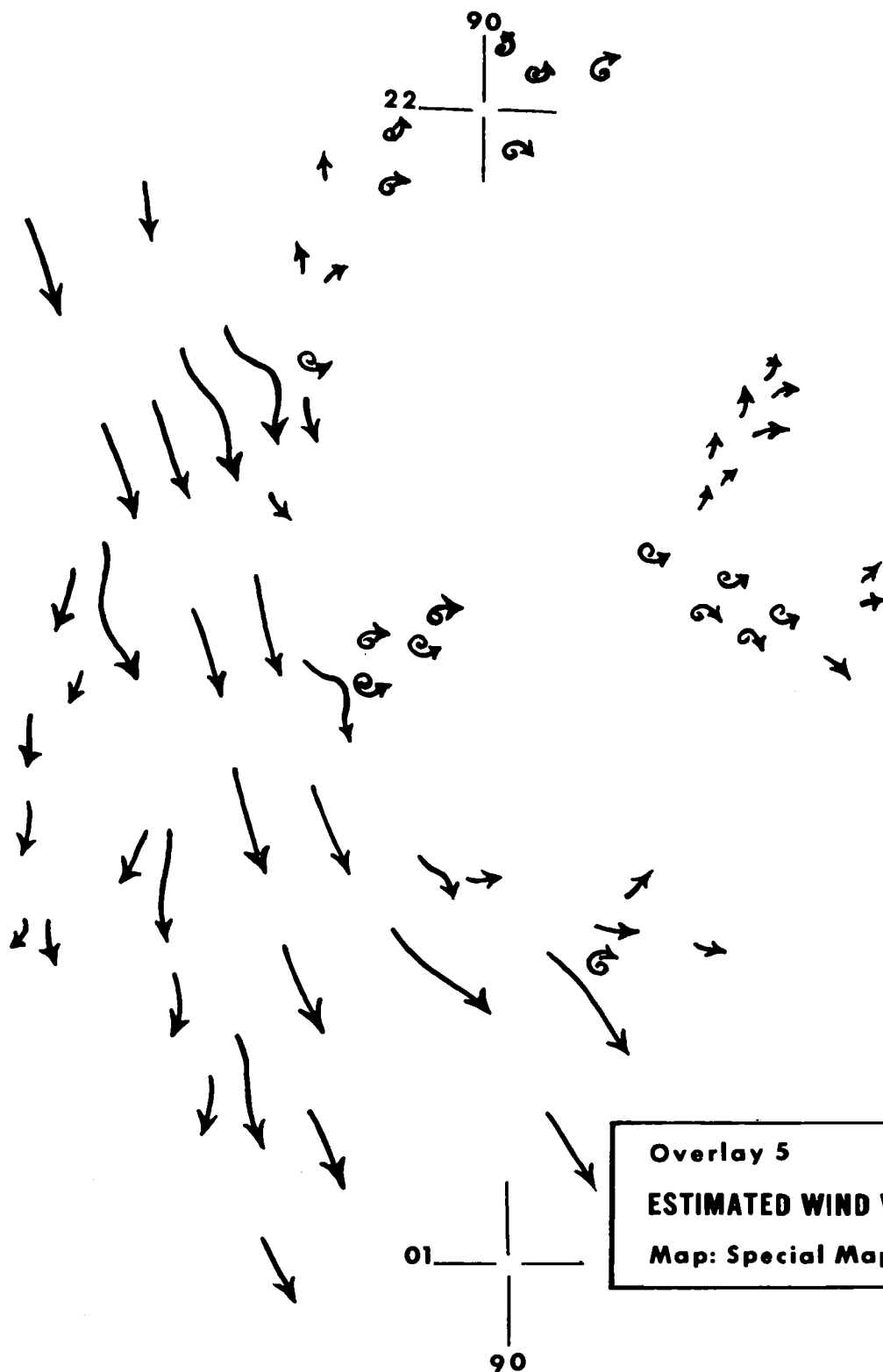
3 Estimated wind vectors at 0600

Figure 46.—Continued.



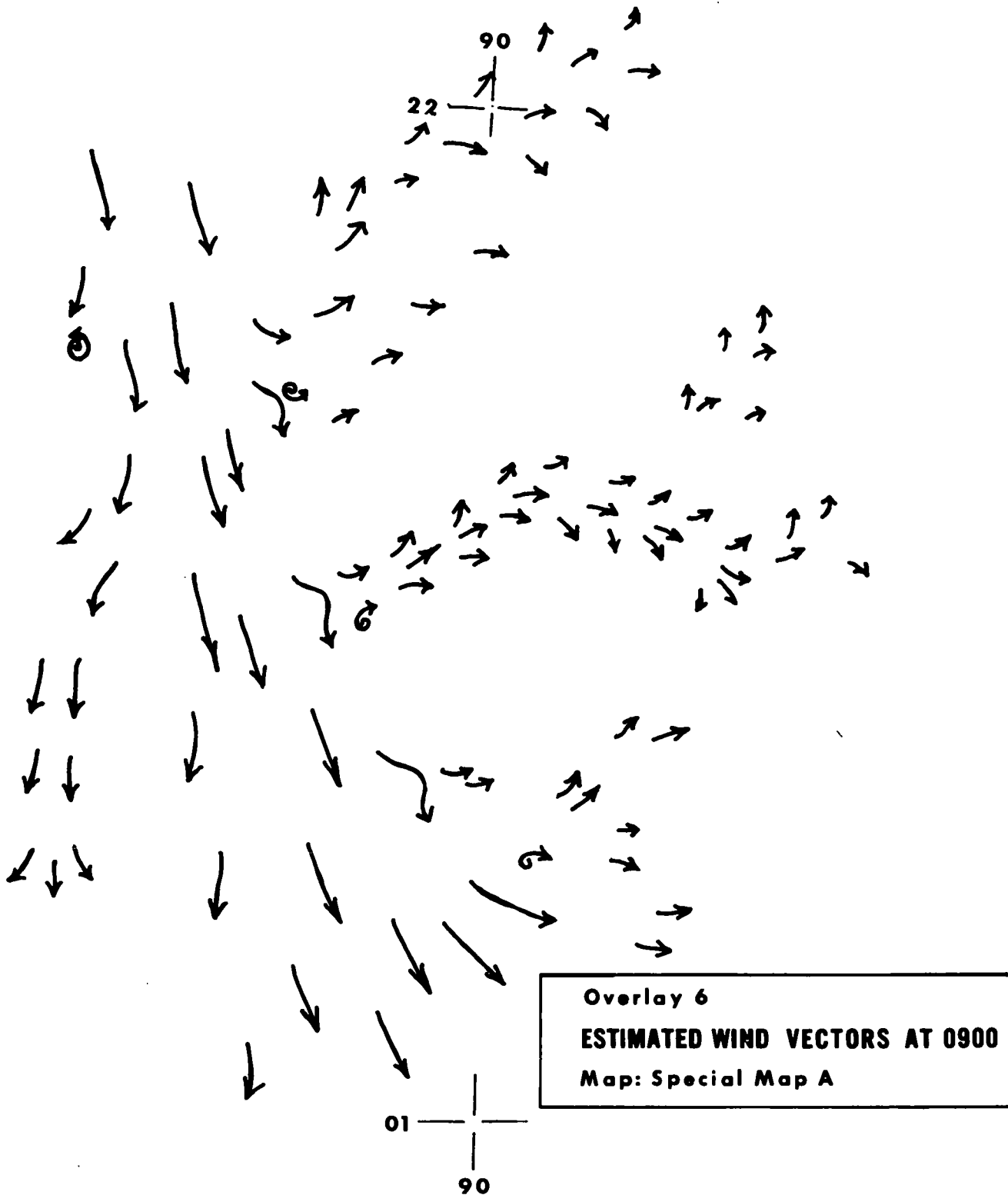
4 Estimated wind vectors at 0700

Figure 45.—Continued.

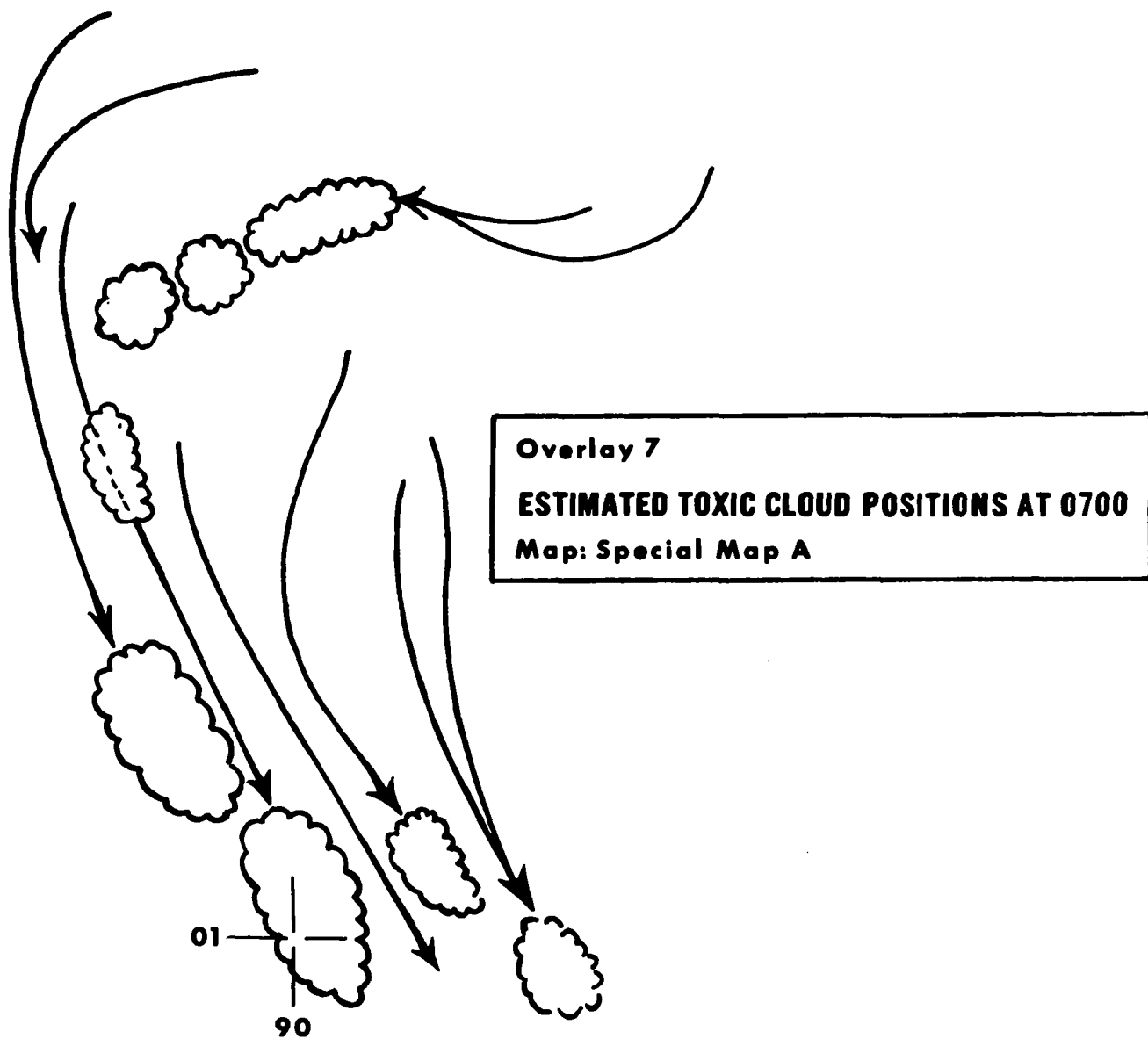
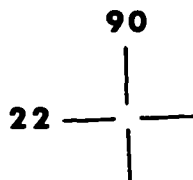


5 Estimated wind vectors at 0800

Figure 45.—Continued.

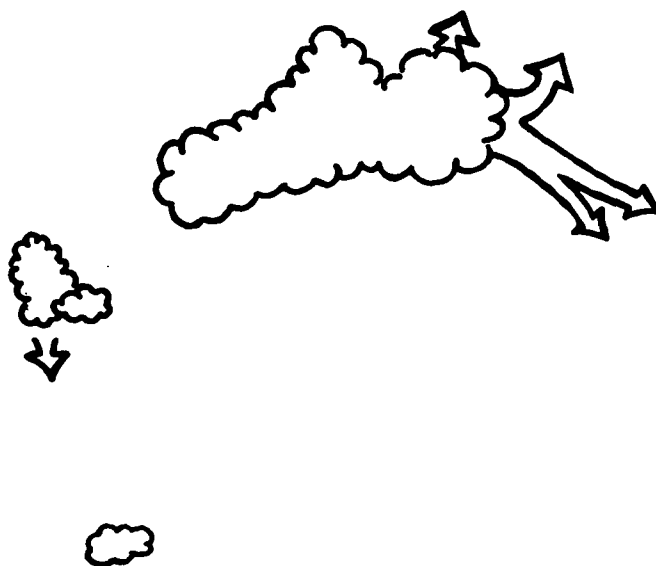
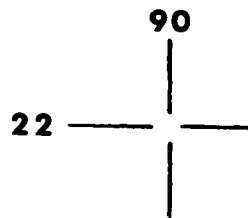


6 Estimated wind vectors at 0900
 Figure 45.—Continued.

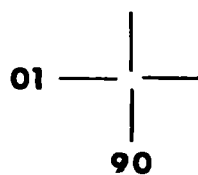


7 Estimated toxic cloud positions at 0700

Figure 45.—Continued.



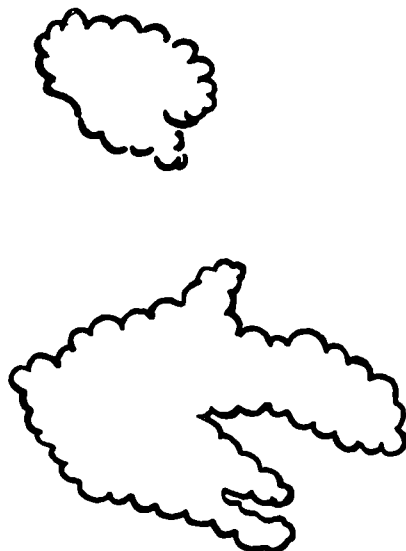
Overlay 8
ESTIMATED TOXIC CLOUD POSITIONS AT 0800
Map: Special Map A



8 Estimated toxic cloud positions at 0800

Figure 45.—Continued.

90
22



Overlay 9
ESTIMATED TOXIC CLOUD POSITIONS
AT 0900
Map: Special Map A

01
90

9 Estimated toxic cloud positions at 0900

Figure 46.—Continued.

Figure 46. Downwind vapor cloud template—scale 1:50,000.
(Located in back of manual)

Figure 47. Downwind vapor cloud template—scale 1:100,000.
(Located in back of manual)

GLOSSARY

Acute—As applied to a disease, it implies a short and relatively severe course.

Bacteria—One-celled micro-organisms, widely distributed, which have no chlorophyll and which can be seen only with a microscope. Some bacteria are disease producing, whereas many others are beneficial.

Biological aerosol decay—The die-off of living organisms in an aerosol cloud.

Blood Cholinesterase Level—The level of cholinesterase in the blood stream which normally is such that it maintains a balanced autonomic nervous system.

Chemical Casualty—A person who has been affected sufficiently by a toxic chemical to render him incapable of performing his functions or duties.

Chemical Operations—The employment of toxic chemical agents to produce casualties among enemy personnel.

Detoxification, Time of—The length of time required for the body to rid itself of a toxic material.

Dosage—The concentration of the agent present in the atmosphere (mg/m^3) multiplied by the time that personnel are exposed to the agent (usually expressed as $\text{mg-min}/\text{m}^3$).

Dosage Contour—A line on a map, representing an imaginary line on the earth's surface, connecting all points of equal dosage values (dosage values expressed in $\text{mg-min}/\text{m}^3$).

Dose—The amount of agent actually absorbed by the body is called a dose.

Endemic—Native to, or prevalent in, a particular region; an endemic disease has a low incidence but is constantly present in a given community.

Equivalent, 155-mm—The ratio of the weight of agent in a particular munition to the weight of agent in 155-mm howitzer munition.

Half life—The time period in which 50 percent of the organisms in storage at some specified temperature die off.

Hectare (ha)—A square 100 meters on each side (0.01 km^2).

Immunity—The state of being resistant to a specific disease. Immunities are not absolute and can be overcome by massive dosages.

Incapacitating Agent—An agent that produces physiological or mental effects that prevent exposed personnel from performing their military duties for a militarily significant period of time and from which there is complete recovery.

Lethal Agent—A chemical or biological substance designed to produce deaths in field concentrations among target personnel.

Liquid Dosage—The amount of liquid toxic chemical agent on the skin of personnel. Only a portion of this dosage is absorbed by the body, the amount varying with the part of the body contaminated, other factors specific for each agent, and the length of time a person is so exposed.

Median infectious dose—The number of micro-organisms that will produce infection in one-half of an exposed population.

Persistency—That property of certain chemical agents of low volatility to remain as contamination for significant periods of time.

Response time—The time interval between the time the decision is made to fire a weapon and the time the fire lands on the target.

Rickettsiae—One-celled parasite micro-organisms, intermediate in size between the bacteria and viruses.

Special Ammunition, Chemical-Filled—Chemical-filled warheads for those items classified as special ammunition are defined in paragraph 2f(1), FM 9-5.

Surprise Attack—A chemical attack in which the desired dosage is delivered on target in 30 seconds.

Total Dosage—The product of agent concentration expressed in mg/m^3 and the total time of exposure.

Toxicity—The property of an agent to produce death or incapacitation.

Vector—An organism, usually an insect, which carries and transmits disease-causing micro-organisms.

Virus—A minute infectious agent, smaller than bacteria and rickettsiae and capable of multiplying only within a living susceptible host cell.

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NG: State AG (3); units—same as Active Army except allowance is one copy to each unit.

USAR: Same as Active Army except allowance is one copy to each unit. For explanation of abbreviations used, see AR 320-50.

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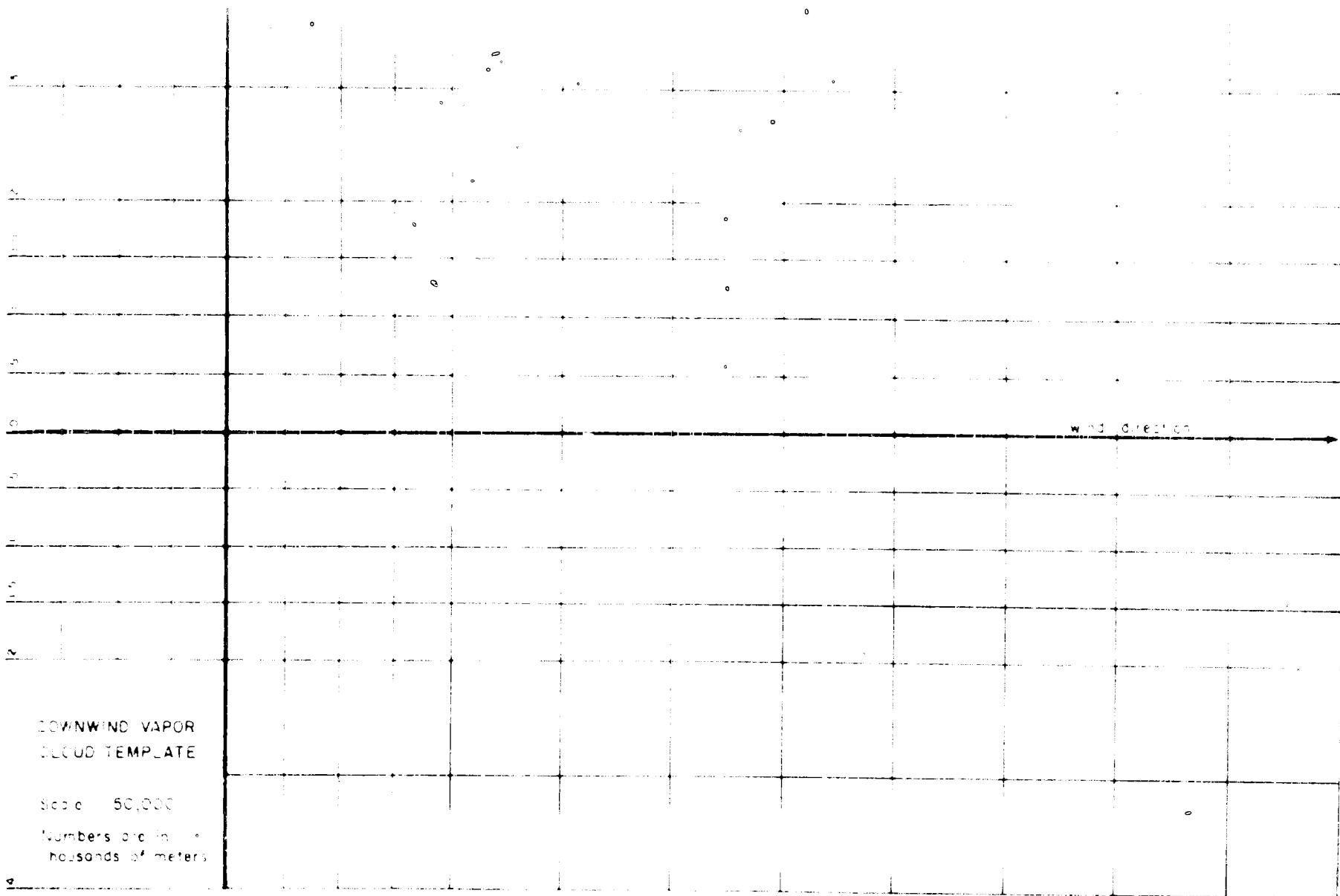
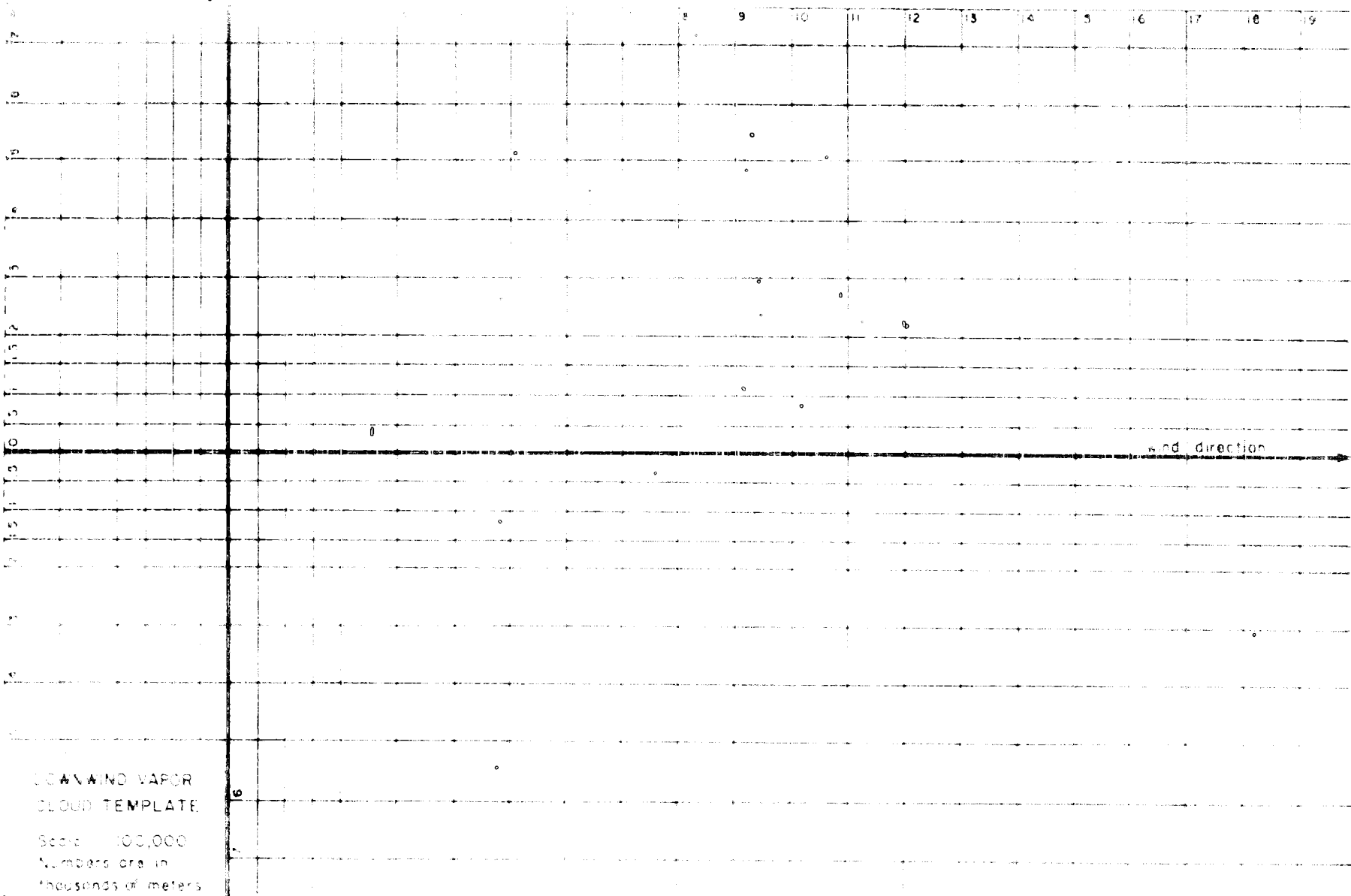


Figure 46. Downwind vapor cloud template—scale 1:50,000.



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